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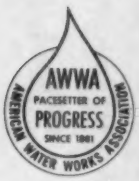
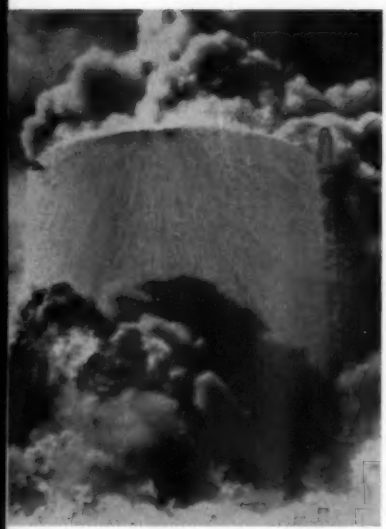


Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 50 • NO. 10



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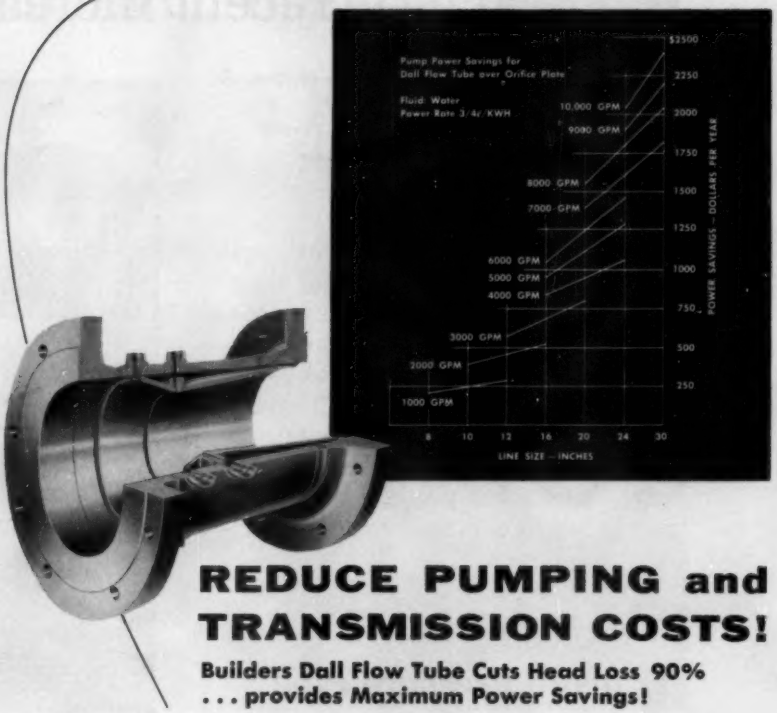

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AWWA SECTIONS

Fall 1958

Oct. 15–17—Iowa Section, at Fort Des Moines Hotel, Des Moines. Secretary, J. J. Hail, Supt., Water Dept., City Hall, Dubuque.

Oct. 19–22—Florida Section, at Golden Gate Hotel, North Miami Beach. Secretary, John G. Simmons, Plant Supt., West Palm Beach Water Co., Box 1311, West Palm Beach.

Oct. 23–24—West Virginia Section, at Daniel Boone Hotel, Charleston. Secretary, Hugh W. Hetzer, Engr., Design & Construction Dept., Union Carbide Chemicals Co., Box 8361, South Charleston 3.

Oct. 23–25—New Jersey Section, at Hotel Madison, Atlantic City. Secretary, A. F. Pleibel, Dist. Sales Mgr., R. D. Wood Co., 683 Prospect St., Maplewood.

Oct. 28–31—California Section, at Ambassador Hotel, Los Angeles. Secretary, Roy E. Dodson Jr., Supt. of Production, Water Dept., Balboa Park, San Diego.

Oct. 29–31—Chesapeake Section, at Hotel Dupont, Wilmington, Del. Secretary, Carl J. Lauter, 6955—33rd St., N.W., Washington 15, D.C.

Nov. 5–7—Virginia Section, at Jefferson Hotel, Richmond. Secretary, J. P. Kavanagh, Dist. Mgr., Wallace & Tiernan Inc., 213 Carlton Terrace Bldg., Roanoke.

Nov. 6–7—Intermountain Section, at Newhouse Hotel, Salt Lake City, Utah. Secretary, William C. Hague, Chief Engr., Metropolitan Water Dist. of Salt Lake City, 703 Tribune Bldg., Salt Lake City, Utah.

Nov. 10–12—North Carolina Section, at O. Henry Hotel, Greensboro. Secretary, D. Y. Brannock, Supt., Water & Sewage Plants, Burlington.

Spring 1959

Feb. 4–6—Indiana Section, at Sheraton-French Lick Hotel, French Lick. Secretary, Chester H. Canham, State Board of Health, 1330 W. Michigan St., Indinapolis 7.

(*Continued on page 10*)

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Coming Meetings

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Mar. 11–13—Illinois Section, at Morrison Hotel, Chicago. Secretary, Dewey W. Johnson, Research Engr., Cast Iron Pipe Research Assn., 3440 Prudential Plaza, Chicago 1.

Mar. 19—New England Section, at Statler Hotel, Boston, Mass. Secretary, J. E. Revelle, Dist. Sales Mgr., Chicago Bridge & Iron Co., 201 Devonshire St., Boston 10, Mass.

Apr. 5–8—Southeastern Section, at Wade Hampton Hotel, Columbia, S.C. Secretary, N. M. deJarnette, Engr., Water Quality Div., State Dept. of Public Health, 309 State Office Bldg., Atlanta 3, Ga.

Apr. 8–10—New York Section, at Powers Hotel, Rochester. Secretary, Kimball Blanchard, New York Branch Sales Office, Neptune Meter Co., 2222 Jackson Ave., Long Island City 1.

Apr. 9–11—Montana Section, at Jordan Hotel, Glendive. Secretary, Arthur W. Clarkson, Asst. Director, Div. of Environmental Sanitation, State Board of Health, Helena.

Apr. 15–17—Nebraska Section, at Cornhusker Hotel, Lincoln. Secretary, Rupert C. Ott Jr., Repr., Neptune Meter Co., 2818—21st St., Columbus.

Apr. 16–18—Arizona Section, at Hi-Way House Hotel, Phoenix. Secretary, Stanford I. Roth, Supervisor of Water Collections, Div. of Water & Sewers, Phoenix, Ariz.

Apr. 22–24—Kansas Section, at Baker Hotel, Hutchinson. Secretary, Harry W. Badley, Repr., Neptune Meter Co., 119 W. Cloud, Salina.

Apr. 23–25—Pacific Northwest Section, at Vancouver Hotel, Vancouver, B.C. Secretary, Fred D. Jones, W. 2108 Maxwell Ave., Spokane 11, Wash.

May 3–6—Canadian Section, at Queen Elizabeth Hotel, Montreal, Que. Secretary, A. E. Berry, Gen. Mgr. & Chief Engr., Ontario Water Resources Com., Parliament Bldgs., Toronto, Ont.

OTHER ORGANIZATIONS

Oct. 27–31—National Metal Exposition & Congress, Public Auditorium, Cleveland, Ohio.

Oct. 27–Nov. 20—Water Works Operators Short Schools, sponsored by Indiana Section of AWWA and Indiana Board of Health, at Purdue Univ., Lafayette, Ind. Basic Course, Oct. 27–30; Operators Course, Nov. 10–13; Management Course, Nov. 17–20. Write: Prof. Harvey Wilke, Civil Engineering Bldg., Purdue Univ., Lafayette, Ind.

Nov. 5–7—Water Works Management Short Course, sponsored by Illinois Section of AWWA and Univ. of Illinois, Allerton Park, Ill.

Nov. 17–19—National Fire Protection Assn., Pittsburgh, Pa.

Nov. 18–20—National Conference on Standards, American Standards Assn., Hotel Roosevelt, New York, N.Y.

Nov. 18–20—National Conference on Air Pollution, Sheraton-Park Hotel, Washington, D.C. For information, write: Malcolm C. Hope, Exec. Sec., Natl. Conf. on Air Pollution, Dept. of Health, Education & Welfare, Washington 25, D.C.

Nov. 30–Dec. 5—American Society of Mechanical Engineers, New York, N.Y.

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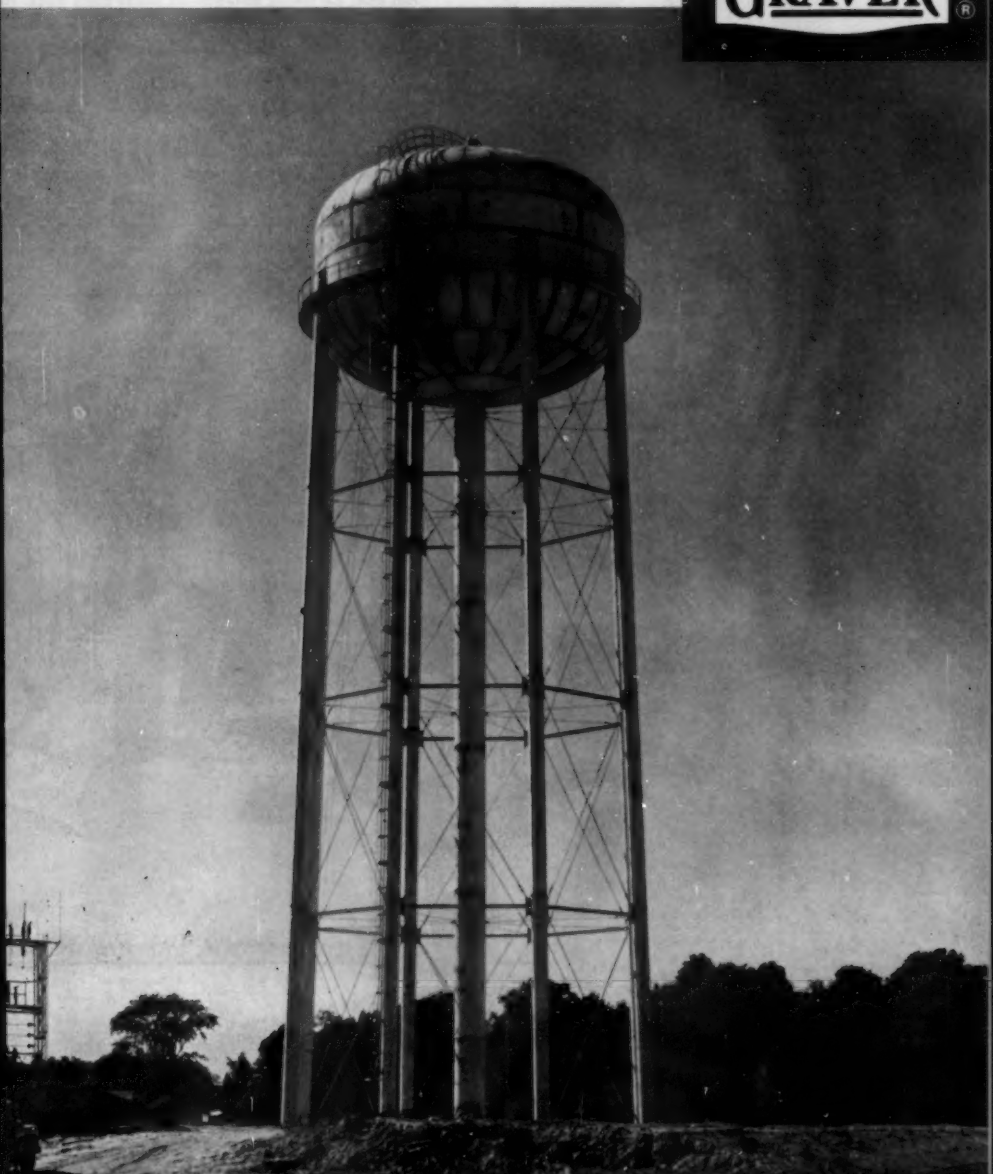


take i

Just what the doctor ordered—an easier day's work. Th
means Tyton Joint® pipe. This ingenious pipe is a cinch
lay... anywhere, any time... even by inexperienced crew

No need for bell holes or caulking... no nuts or bo
to fasten. Simply fit a specially designed rubber gask

"NO HARD WORK FER A SPELL, LUKE...
BUT YOU KIN STILL LAY TYTON."

U.S. cast iron PIPE FOR WATER, SEWERAGE AN

easy!

nto the bell, and slide in the connecting pipe.
he gasket insures a tight, permanent seal. And you
an lay Tyton Joint pipe in wet trench or rain.

all or write for complete details as to how
yton Joint can save you time, money, trouble.

. S. PIPE AND FOUNDRY COMPANY
eneral Office: Birmingham 2, Alabama

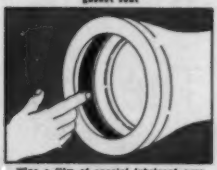
WHOLLY INTEGRATED PRODUCER FROM MINES
ND BLAST FURNACES TO FINISHED PIPE

DUSTRIAL SERVICE

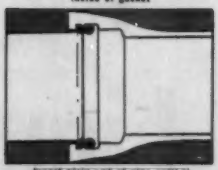
TYTON

ONLY FOUR SIMPLE ACTIONS

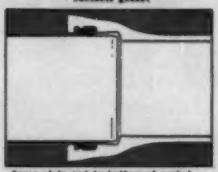
Insert gasket with groove over head in gasket seat



Wipe a film of special lubricant over inside of gasket



Insert plain end of pipe until it contacts gasket



Force plain end to bottom of socket... the job's done!

Tyton Joint pipe for water main extension in Oklahoma.

Add to these benefits of

Cyanamid Alum

- Maximum adsorption of suspended and colloidal impurities
- Forms floc rapidly—coagulates in wide pH range
- Uniform feed—and a purity that minimizes equipment corrosion

The extra advantages of

Cyanamid Liquid Alum

- Easy unloading—no bags—compact storage—and turn-of-the-valve handling
- Consistent concentration that permits automatic metering, accurate gauging
- Cleaner—more efficient operation—greater flexibility with less man power
- Quick pay-off on dry-to-liquid conversion because of lower costs.

...and let Cyanamid help you with *technical service* based on long experience with dry and liquid alum installations. *Product service* from 9 shipping points, in bags, tank cars or tank trucks.

CYANAMID

AMERICAN CYANAMID COMPANY

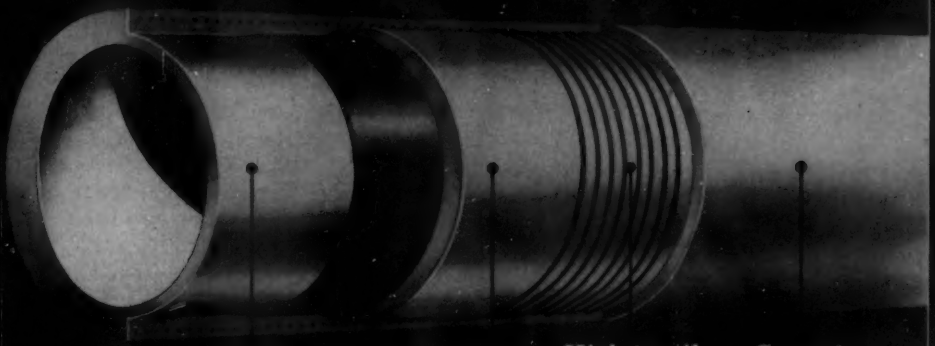
Process Chemicals Department

30 ROCKEFELLER PLAZA, NEW YORK 20, NEW YORK

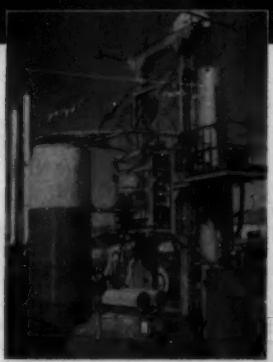
In Canada: Cyanamid of Canada Limited, Montreal and Toronto

PRESTRESSED
CONCRETE CYLINDER PIPE
(Embedded Cylinder Type)

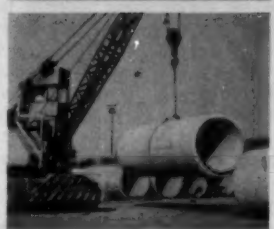
with Rubber Gasket Joint



All of the good qualities and characteristics desired by water works engineers for permanent water supply and transmission lines are embodied in this prestressed pipe of advanced design: great strength, sustained high carrying capacity, trouble-free service, and unusually long life. Prestressed pipe of this type can be designed more accurately, predictably and economically for most all conditions of internal pressure and external loads than any other type of high quality concrete pressure pipe. It is the finest quality pipe available in medium and large diameters for pressures generally ranging from 100 psi upward. American is currently undertaking the manufacture of this pipe designed for pressures ranging from 275 to 550 ft. of head for a portion of the U.S. Bureau of Reclamation Project being constructed for the Ventura River Municipal Water District. This Ventura River Project will serve 32 square miles of mountainous country with water for irrigation, municipal and industrial use in main and coastal reaches of Ventura County, California. When planning *your* future water "growth lines," look to American's quality pipe line products, extensive production facilities and half century of experience.



Prestressing machine wraps high tensile steel wire under carefully measured tension around pipe core.



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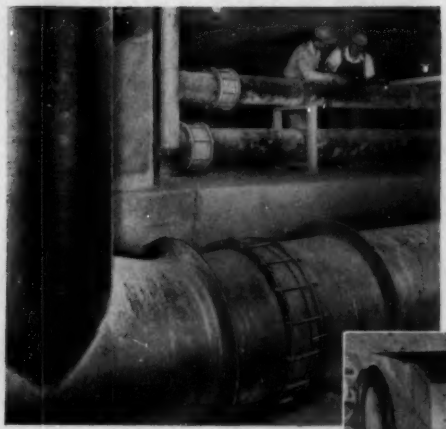
SAN DIEGO: P.O. Box 13—CYpress 6-6166
PHOENIX: 2025 South 7th St.—ALpine 2-1413
PORTLAND: 518 N.E. Columbia Blvd.—BUtler 5-2531

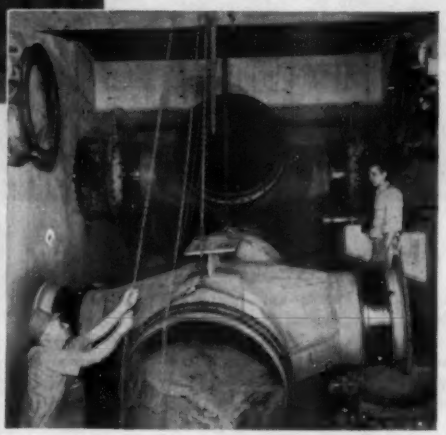
CONCRETE PIPE FOR MAIN WATER SUPPLY LINES, STORM AND SANITARY SEWERS, SUBAQUEOUS LINES

Joining pipe the Dresser way...



Always the easy way...

The 8-inch, 10-inch and 30-inch Dresser-Coupled lines illustrated here are part of the system used in servicing the Clague Road's advanced rapid-sand type filters.



often the only way!

This battery of steel crosses is in the new Clague Road Filtration Plant, designed by Havens and Emerson, Cleveland, Ohio. The Plant will carry a normal flow of 50-million gpd. Contractor: Hunkin-Conkey Construction Company.

Dresser® Couplings provide the essential leeway for bolting up cross flanges to valves in tight spots. They'll take deviation caused by settling concrete and remain bottle-tight... permanently! Dresser's vibration-proof properties protect valves and other expensive equipment, and protect the pipelines, too. With a Dresser Coupling, two man-minutes per bolt gives you a permanent, leak-proof joint that absorbs expansion-contraction movement, keeps maintenance problems to a minimum, and makes repairs easier if and when they do become necessary. For a free copy of "Dresser Couplings for Filtration Plant Piping" and the Dresser Sewage Treatment Plants booklet, write to Dresser Manufacturing Division, Bradford, Pennsylvania.

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DRESSER
MANUFACTURING DIVISION

ONE OF THE DRESSER INDUSTRIES

WATER DEPARTMENT, CHIEF ENGINEER

Planner of Operations, Judge of Quality

He says, "I recommend American Meters because of their advanced engineering, their simplicity and complete frost protection."

Men who have an engineering background appreciate the advanced design features of American Meters. They know that such features as the simplicity, the ruggedness, the thicker measuring disc, the transparent hard tenite plastic register cover, the "O" ring stuffing and packing, the ease of disassembly and assembly are the result of sound engineering knowledge and years of meter experience.

"Yes...", as Chief Engineer of the Water Department, "I recommend American Meters every time."

Use American Meters with sealed plastic register box for pit installation.

BUFFALO METER CO.

2914 Main Street • Buffalo 14, New York

Engineering PLUS...

Keeps Tank Interiors Corrosion Free at a Practical Cost

One of the five municipal tanks serving the City of Jacksonville, Fla. which has been cathodically protected by E.R.P. system since 1942.

The City of Jacksonville, Fla. has relied on engineering plus from Electro Rust-Proofing Corp. since 1942 to protect water storage tanks serving the city. Since installation of cathodic protection, tanks have been virtually corrosion free on the under water surfaces and maintenance costs have been reduced to a minimum.

E.R.P. engineering plus means cathodic protection systems
designed to meet your needs...
maintained to your benefit...
priced to your profit...

E.R.P. provides engineering plus to meet any corrosion problem of submerged or buried metals. For full information on cathodic protection for your water storage tanks, water treatment structures and pipelines, write for bulletin E-42.05.

ERP CATHODIC PROTECTION SINCE 1935

ELECTRO RUST-PROOFING CORP.
A SUBSIDIARY OF WALLACE & TIERNAN INC.
30 MAIN STREET, BELLEVILLE 9, NEW JERSEY
CABLE: ELECTRO, NEWARK, N. J.

NOW!

improved...
streamlined...
modernized...the

EDDY Hydrant
has ALL these features...

★ *Optional ground line break flange*
★ *Large diameter barrel for increased flow*
★ *O-ring or standard packing*
★ *New self-sealing rubber ring main valve packing*
★ *No lubrication required for fast, easy opening*
★ *Opens with the pressure—for instantaneous flow*
★ *Closes against the pressure—eliminates water hammer*

Optional break flange gives double protection against impact damage

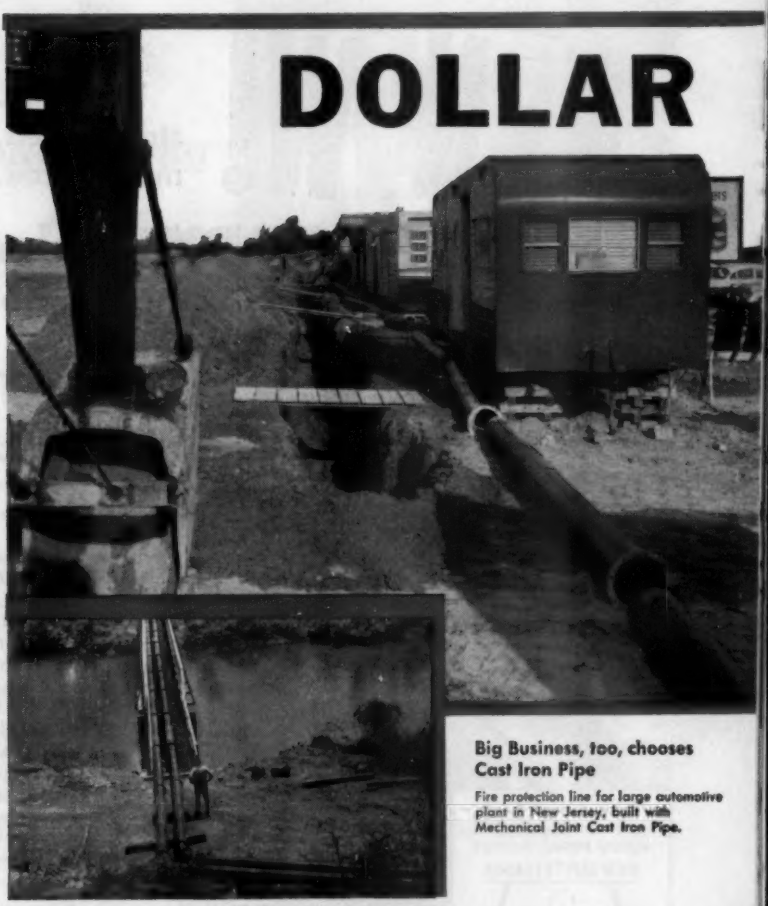
The EDDY Hydrant...improved... streamlined...modernized...retains all the basic advantages that have made these hydrants outstanding for four generations. Yet, it has important new advanced design features which provide the utmost in efficient, dependable, longlife fire protection service.

These new important advantages are provided without sacrificing interchangeability of working parts with EDDY hydrants now in service. Now, more than ever, EDDY offers maximum fire protection, economical maintenance and assurance against future obsolescence in your fire-fighting system.

Before buying or specifying hydrants, be sure you know how these advantages may benefit your community.

EDDY VALVE COMPANY
A Subsidiary of James B. Eflow & Sons, Inc.
WATERFORD NEW YORK

DOLLAR



Big Business, too, chooses Cast Iron Pipe

Fire protection line for large automotive plant in New Jersey, built with Mechanical Joint Cast Iron Pipe.

Ash disposal line for power plant in Alabama, being constructed with 12" Mechanical Joint Cast Iron Pipe.

MODERNIZED **cast iron**

FOR DOLLAR

Cast Iron Pipe delivers MORE water...LONGER!

Pipe is a capital investment.

But cast iron pipe is an investment that pays off.

- *In longer life* . . . cast iron pipe serves for centuries.
- *In more efficient operation* . . . cast iron pipe requires little or no maintenance or replacement.
- *In taxpayer satisfaction* . . . cast iron pipe far outlasts the bond issue that paid for it.

Most important to you, these statements are based on proof, not claims . . . performance, not promise. Specify cast iron pipe, America's most dependable pipe, and be sure, not sorry.

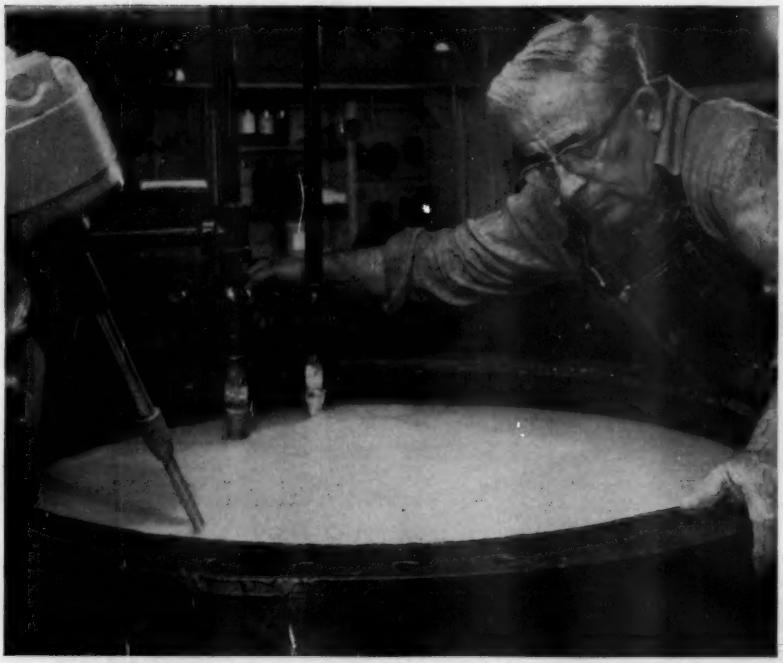
THE MAN WHO CHOOSES CAST IRON PIPE TODAY WON'T PAY FOR IT AGAIN TOMORROW!

Cast Iron Pipe Research Association
Thos. F. Wolfe, Managing Director
Suite 3440, Prudential Plaza, Chicago 1, Ill.

6 reasons why Cast Iron Pipe is #1 choice of U. S. A.

1. HIGH FLOW CAPACITY . . . Cement lined cast iron pipe and fittings will not tuberculate . . . delivers a full flow for the life of the pipe.
2. LONG LIFE . . . 42 North American cities are still using cast iron water mains laid 100 years and more ago. Hundreds more have passed the 50 year mark.
3. BEAM STRENGTH . . . Cast Iron Pipe is inherently tough . . . stands up under heavy traffic load, soil displacement and disturbance.
4. EXTERNAL LOAD RESISTANCE . . . 6" Class 150 Pipe withstands a crushing load of 17,900 pounds per foot . . . nearly 9 tons.
5. CORROSION RESISTANCE . . . Cast Iron Pipe effectively resists corrosion . . . vital factor in its long life and dependability.
6. TIGHT JOINTS . . . A full range of leak-proof, low cost, easy-to-assemble joints for pipe and fittings are available for all conditions.

pipe FOR MODERN WATER WORKS



Slurry-Feeding Hagan Coagulant Aid No. 18

HAGAN COAGULANT AIDS SOLVE COLOR PROBLEM FOR WOOLEN MILL

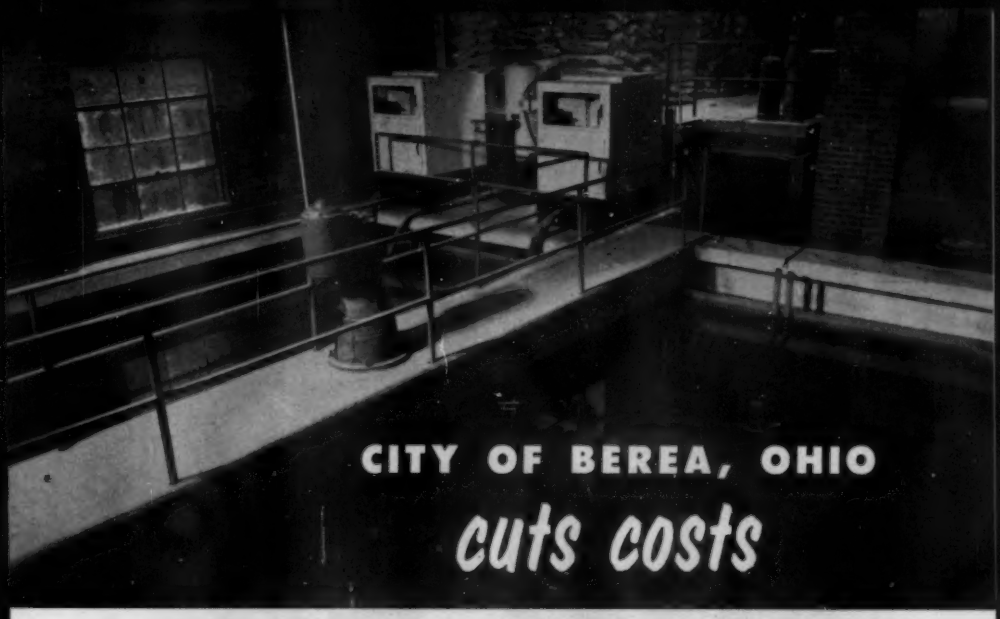
J. J. O'Donnell Woolens, Inc. produce cashmere and high quality ladies woolen goods, specializing in pastel shades. They are located downstream of a steel mill, a sewage plant and several other woolen mills. During summer droughts and in extremely cold weather the high organic color and detergent content of Blackstone River water created a difficult clarification problem. Even with heavily increased alum dosages, color removal was poor, frequently necessitating reprocessing of the delicate shades.

Over two years ago, after laboratory tests, the plant adopted the use of Hagan Coagulant Aid No. 18 during periods of high color. Alum dosage has been reduced by 25%, with good floc formation and sedimentation. Color removal is excellent. The plant states: "During the long drought last summer, we doubt that we could have operated without Hagan Coagulant Aid No. 18."

Hagan Coagulant Aids are non-toxic, easy to handle, easy to feed and produce a large tough floc that speeds settling time and reduces carryover. Hagan Aids may be dry-fed or slurry fed to meet plant conditions. Write for Bulletin 410-12-2 for information on the complete line of Hagan Coagulant Aids.

CALGON COMPANY

DIVISION OF HAGAN CHEMICALS & CONTROLS, INC.
HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY, HALL LABORATORIES
IN CANADA: HAGAN CORPORATION (CANADA) LIMITED, TORONTO



CITY OF BEREA, OHIO *cuts costs*

New Cochrane SOLIDS-CONTACT REACTOR *combines*

mixing, precipitation, sludge concentration, clarification & softening

The relatively hard, turbid Rocky River supply for the city of Berea, Ohio, is quickly reduced in hardness to approximately 3.5 gr/gal and to a turbidity of less than 10 ppm by the Cochrane Solids-Contact Reactor shown above. An existing concrete basin 28′ square x 15′ deep was modernized by conversion to the Solids-Contact type. Using hydrated lime, soda ash and alum, the Reactor treats over 2,000,000 gpd at surprisingly low cost.

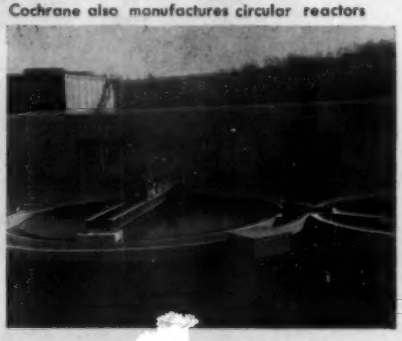
Because the design of the Cochrane Reactor provides higher quality treated water faster, in less space, with minimum chemicals, their use has grown tremendously for municipal applications. High slurry strength in the reaction zone speeds precipitation—there is very little waste water. Automatic desludging saves time and labor. In addition to softening and clarification, Cochrane Reactors remove color, taste, odor; reduce alkalinity, silica, fluorides, etc.

Cochrane's background in water conditioning makes possible the installation of complete systems under a single responsibility for continued, consistent performance. Write for Publication 5001-A and case history reprints.

Cochrane
CORPORATION
3124 N. 17TH STREET, PHILADELPHIA 32, PA.
NEW YORK • PHILADELPHIA • CHICAGO

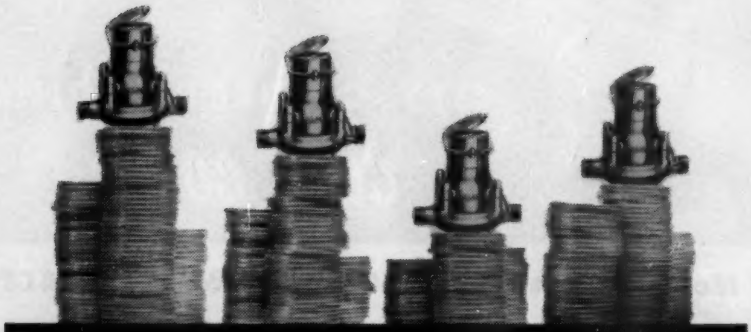
Representatives in 30 principal cities in U.S.; Toronto, Canada; Paris, France; Mexico City, Mexico; La Spezia, Italy; Havana, Cuba; Caracas, Venezuela; San Juan, Puerto Rico; Honolulu, Hawaii; Malmo, Sweden; Santiago, Chile. Pottstown Metal Products Division—Custom built carbon steel and alloy products.

Cochrane also manufactures circular reactors



Demineralizers • Hot Process Softeners • Hot Zeolite Softeners • Dealkalizers • Reactors
Deaerators • Continuous Blowoff • Condensate Return Systems • Specialties

How to get more revenue per meter



STANDARDIZE ON

CALMET

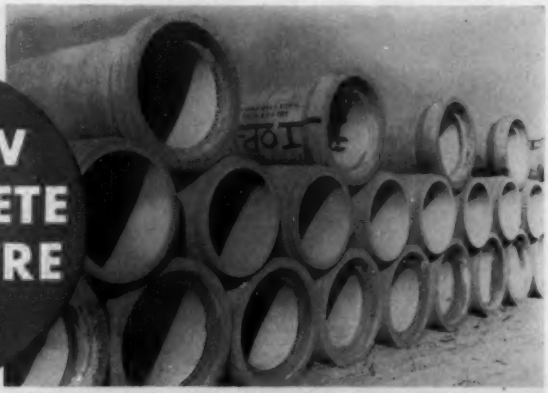
All-bronze split-case Water Meters

Eliminate revenue loss thru SUSTAINED ACCURACY
Save operating costs through
MINIMUM MAINTENANCE

designed for revenue . . .

CALMET
METER DIVISION
WORTHINGTON CORPORATION
2301 SO. MAIN • FORT WORTH, TEXAS

A NEW CONCRETE PRESSURE PIPE



of unequalled ECONOMY

Recently, a large chemical company in Louisiana selected Cen-Vi-Ro Concrete Pressure Pipe to move fresh water into its new plant. Cen-Vi-Ro easily exceeded the hydrostatic and other test requirements, insuring the owners a permanent and maintenance-free installation. The close tolerances of Cen-Vi-Ro's precision-formed joints . . . measured in thousandths . . . combined with special O-ring type Rubber Gasket Seal assure perfect leakproof connections under even the most adverse field conditions.

Lower first cost plus longer lengths result in a more economical installation . . . *every time!*

Write for complete Cen-Vi-Ro information . . .

THE NAME, ITSELF, MEANS THE WORLD'S FINEST PIPE!

CEN — comes from CENtrifugally spinning the very dry "earth-moist" mixture, fed into the form by belt conveyor in uniform layers.

VI — comes from VIbration of the spinning form during the charging period. Specially designed vibrator-tampers on the underside of the form do this job.

RO — comes from ROlling the mixture under great pressure applied by a specially designed steel roller.

"Organized for Service"

Vulcan Materials Company

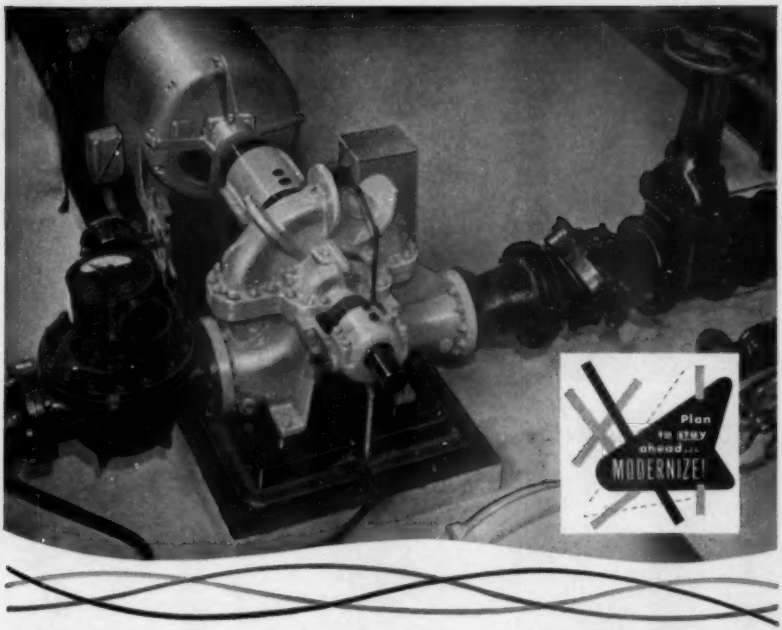
Vulcan Materials Company

CONCRETE PIPE DIVISION

P. O. BOX 6226 • STATION H • ATLANTA, GEORGIA

Telephone JAckson 4-6243

A Division of Vulcan Materials Company



Save as much as $4000.00

with an Allis-Chalmers Type SJD Pump

Here's proof: *one* Allis-Chalmers Type SJD pump (double-suction, horizontal split-case construction with double volute) can provide 3000 gpm capacity with a 500-foot head. Range — 1000-7000 gpm at 1800 rpm.

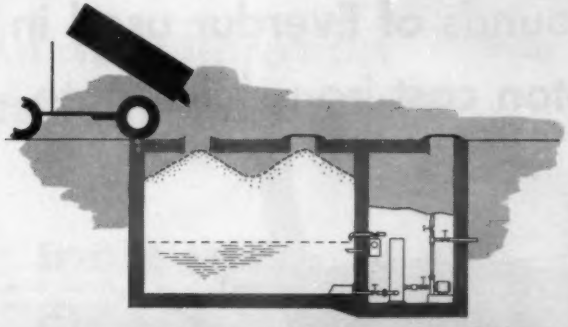
Without SJD design — *exclusive from A-C — two* pumps in series or a multi-stage pump is needed . . . and *up go* equipment costs and installation costs.

In addition to initial savings, Type SJD application *saves* up to 33% in floor space. You *save* too on maintenance, thanks to single-unit application.

Allis-Chalmers offers a full line of pumps for municipal water supply, and all offer proven reliability. Contact your A-C representative or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

A-C ALLIS-CHALMERS

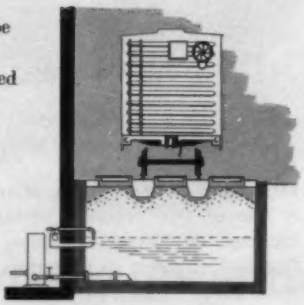
A-5791



SALT DELIVERY

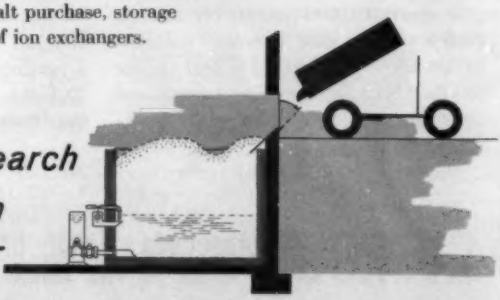
How it can affect design of water softening installations

Every method of salt delivery—by rail, truck or barge, in bags or bulk—presents it own special problems of plant design. For example: What plant area should be designated for receiving salt? What's the best salt-unloading method to specify? Where will salt be stored and dissolved to make brine? The job of answering these questions has been complicated in recent years by the greatly increased salt tonnages required in today's large-capacity water-softening installations.



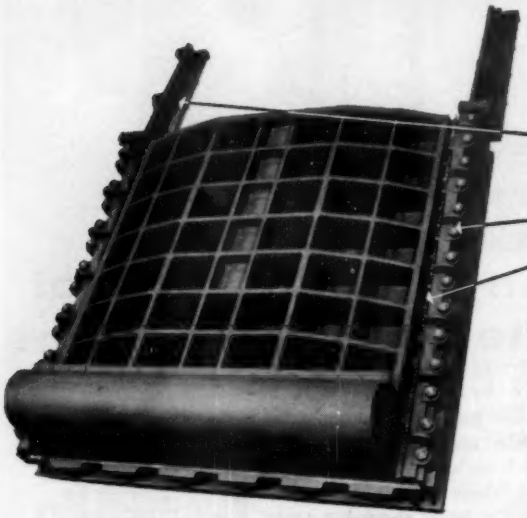
If you foresee a plant-design problem involving salt delivery, contact International Salt Company. With over 50 years of experience and continuing research in all phases of salt handling and brine production, International is fully prepared to give you expert, comprehensive information and technical assistance on any matter in connection with salt purchase, storage and dissolving for regeneration of ion exchangers. This service is free of charge.

Service and research are the extras in STERLING SALT



INTERNATIONAL SALT CO., INC., SCRANTON 2, PA. • **Sales Offices:** Atlanta, Ga. • Baltimore, Md. • Boston, Mass. Buffalo, N. Y. • Chicago, Ill. • Cincinnati, O. • Cleveland, O. • Detroit, Mich. • Memphis, Tenn. • Newark, N. J. New Orleans, La. • New York, N. Y. • Philadelphia, Pa. • Pittsburgh, Pa. • Richmond, Va. • St. Louis, Mo.

2,300 pounds of Everdur used in new 8-ton cast-iron sluice gate



1 ¾" x 3" Everdur facing strips for gate leaf and frame.

2 1½" Everdur bolts and nuts.

3 Everdur adjusting bolts for cast-bronze wedges.

More than a ton of Everdur was used for facing strips and fastenings in this 8' x 8' sluice gate leaf and frame assembly designed and furnished by the Coldwell-Wilcox Division of Krajewski-Pesant Mfg. Corp., New York City. Consulting engineers, Gannett Fleming Corddry & Carpenter, Inc., Harrisburg, Pa.

This direct-pressure type sluice gate is one of two recently installed by Empresa de Energia Electrica at the Quebradona Dam in Columbia, South America, to regulate the flow of potable water to the city of Medellin.

The 100-foot head of water behind the dam exerts 450,000 pounds pressure on each 8 x 8-foot gate. Everdur* (copper-silicon alloy) was selected to seal against this load because of its high strength and corrosion resistance—plus ready workability and weldability. Sewage treatment and water works equipment of Everdur has been in service without replacement for a quarter century and longer.

Write for Publication E-11, "Everdur Copper-Silicon Alloys for Sewage Treatment and Waterworks Equipment"—or for technical help in selecting the correct material for your job. Address: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Limited, New Toronto, Ont.

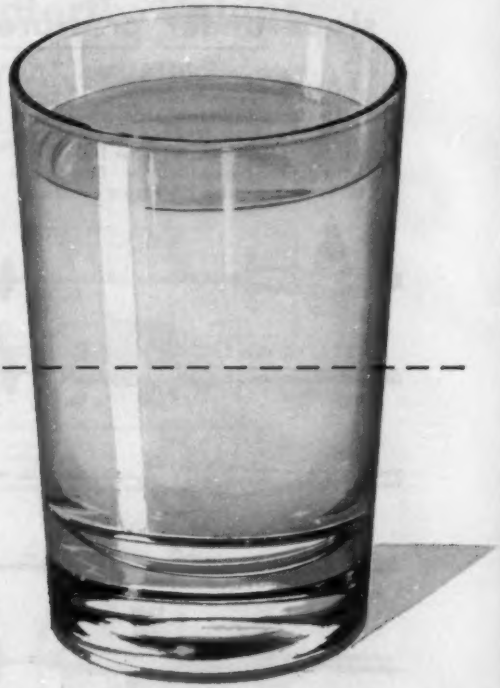
*Reg. U.S. Pat. Off. 57133

EVERDUR Anaconda's Family of Copper-Silicon Alloys
MADE BY THE AMERICAN BRASS COMPANY
STRONG · WORKABLE · WELDABLE · CORROSION-RESISTANT

NOW...

cut new filtration plant costs 45%

Increase clear water capacity 100%



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†Comparison Studies of Diatomite and Sand Filtration by G. R. Bell, Journal American Water Works Association, September, 1956.

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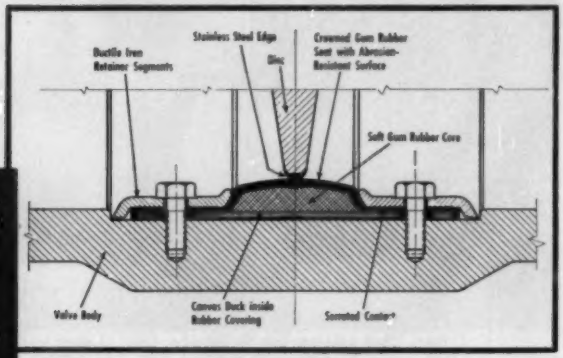

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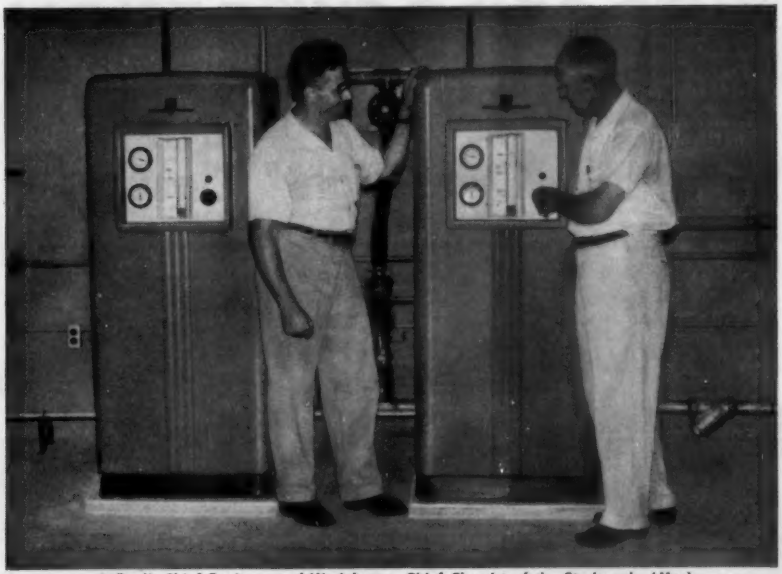

J. Pauli, Chief Engineer and W. Johnson, Chief Chemist of the St. Joseph, (Mo.) Water Company, discuss operation of their W&T V-notch chlorinators. The St. Joseph Water Co. is part of the American Water Works Service Co., Inc. system.

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Journal

AMERICAN WATER WORKS ASSOCIATION

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AWWA's Public Information Program

Fred Merryfield

A paper presented on Apr. 21, 1958, at the Annual Conference, Dallas, Tex., by Fred Merryfield, Prof. of San. Eng., Oregon State College, Corvallis, Ore.

REVIEWING the objectives of AWWA, one finds that it was founded to do the following things:

1. Advance the knowledge of the design, construction, operation and management of water works
2. Consider and deal with the problems involved in the production and distribution of safe and adequate water supplies
3. Promote a satisfactory relationship with the consuming public
4. Give proper consideration to and express opinions upon practices that will enable the industry to render the best possible service to the public
5. Do whatever things are necessary and proper for the accomplishment of the objectives herein set forth—all of which shall be consistent with the public interest and with interests of the water works industry. The membership of the Association consists of persons interested in such matters and in accord with the above objectives.

The present members of the Association have inherited skills and knowledge gained through the rich and fruitful labors of the members now departed, and have learned from them to produce a good quality water for customer consumption and to develop systems and equipment for production and distribution. The Association has stressed less, however, the promotion of a satisfactory relationship with the consuming public, and it has failed for the most part to protect the interests of the water works industry, its personnel and managers. Although it is proud of its membership growth and its representation of the American water works industry, the Association still needs to gather to itself more personnel who are engaged in water utility operations.

The Association has for years been engaged both directly and indirectly in public relations activities, and in the development of good management and financial practices. It is the consensus of the Committee on Water Works Advancement, of preceding committees, of present and previous boards, that there is too little public recognition and appreciation of the fundamental value of water works service to the health,

comfort, and prosperity of the individual and the community.

There is little public realization of the need for the development and growth of public water supplies. Few, if any, of the customers and not too many of the directors, commissioners, or council members appreciate the margins of safety under which a water utility should operate. Nor are they aware of the time required for, cost of, and time to undertake advance planning.

The public, the individual customer, commissioner, or councilman all recognize that good service requires good organization, and yet very few recognize that adequate service must be backed by adequate rates. Can good systems be maintained, operated and enlarged at 5 cents a ton? Can the customer appreciate the meaning of this?

Isn't it the utilities' job to inform their customers, commissioners, directors, and councilors?

A countrywide survey of the physical health of the water utilities in this country reveals that: [1] 20 per cent are deficient in supplies; [2] 40 per cent are deficient in transmission capacity; [3] 30 per cent are deficient in pumping capacity; [4] 40 per cent are deficient in treatment capacity; [5] many more require treatment facilities to provide that quality wanted by the customers; [6] 30 per cent are deficient in ground storage; [7] 40 per cent are deficient in elevated storage; and [8] 60 per cent need improvements in distribution systems.

Many water utilities need to undertake measures to place them on an improved business basis, to sell more water, and encourage steps toward improved water use.

The American water works industry must be prepared to spend $750,000,000 each year just to keep the systems up to present standards—and these are not high enough. The business climate and the financial market are favorable for a concerted program to bring water supply systems into balance.

The water industry can set in motion "Operation Bootstrap" without federal or state aid in most cases, and AWWA has suggested this to President Eisenhower. A water utility is, or should be, a business able to stand on its own feet.

The qualified personnel of water works are underpaid compared to those with similar positions in sister utilities and industries. Many of them, particularly in management and engineering, are grossly underpaid for the responsibilities they shoulder so well. There are too many untrained water works employees, and too few trained, entering the industry. Too many qualified, faithful, dedicated, and devoted employees in this industry are unrecognized. There are too many discouraged managers, defeated rather than inspired by the importance and difficulties of their position. There is no water system or organization that does not need improvement.

On Apr. 21, 1958, the Board of Directors approved "Operation Water Works Advancement," which was suggested by the Public Information Committee. This program is intended not merely to increase the public knowledge of the technical problems of water works development, but also to increase understanding of its basic conditions, problems, responsibilities, accomplishments, weaknesses, and ways and means of improvement. The public must be told of the advantages stemming from good, adequate, self-sustained water systems, with the objective of creating and maintaining improved service.

AWWA Water Works Advancement Program

John H. Murdoch Jr.

A paper presented on Apr. 21, 1958, at the Annual Conference, Dallas, Tex., by John H. Murdoch Jr., Consultant, AWWA Water Works Advancement Program, Wynnewood, Pa.

THE AWWA Committee on Water Works Advancement formerly was the Committee on Public Information. Its name has been changed because the old title emphasized only one means for reaching the ultimate goal of water works advancement. It is important to keep attention focused on the end rather than on the means to it.

Public information for the water works industry does not merely mean increasing public knowledge of water supply facts. It implies, rather, increasing public appreciation of all that water supply means to urban life and development. The public should be aware of the many problems and responsibilities of the water industry, as well as the skill, training, energy, devotion to public duty, courage, and imagination required to meet and overcome all the complex situations that must be faced if communities are to be adequately supplied with water. Public information is intended to create this appreciation and help the general public, public officials, and the voters to understand what good water systems are, their value, desirability, and cost—and that they are worth the cost. Public information is also expected to advance water works systems, to improve service, and bring in the day when each community will have a self-sustained water supply system, able to meet the growing needs of the community.

One point should be given special emphasis: The men of the water industry have not started on this "Operation Water Works Advancement" to pat themselves on the back. They do want public appreciation of their achievements and problems, better understanding of their handicaps, and recognition of what needs to be done, but the pat on the back is not the objective. The objective is improved service, and perhaps a prod is needed more than a pat.

AWWA, both nationally and through its sections and committees, exists in order to help the local water system. This is true of the work of the new committee. It exists because of local needs, and its work must for the most part depend on local action. It will work with and through the AWWA sections to give encouragment, suggestions, and help to local management. The effort has been and is continuing to be made nationally to create both a public consciousness of water supply problems, and a climate favorable to the growth and improvement of water service. Through suppliers' national advertising much has already been accomplished in this respect, and more is to come. The sections of AWWA, through newly created committees, will carry the work closer to

the various communities. They will create speakers' pools, encourage school programs, and offer training schools, seminars, or short courses for managers.

Local Efforts

The final responsibility for gaining public support rests with the local water system management. The national committee, Association officers, and sections will keep up the drive and will help in various ways, but a convinced, dedicated, trained local management must be depended upon to bring to each community the self-sustained water system and service needed to keep up with growing demands.

One way local water system managements can help the general movement and take steps toward local goals is by making the very best possible use of existing facilities. If a local organization wants better recognition and wants to be entrusted with the development of improved systems, then that local management organization must earn and maintain public confidence by making the best, most efficient use of what is at hand. The public should not be asked to give new responsibilities to those who fail to measure up to their opportunities.

Local management must create a water works team devoted to improved service. This team should realize the need for training, the complexity of public water supply, the need for advance planning and preparation today for conditions anticipated 10–20 years or more in the future, and the dependence of adequate service on realistic, adequate revenues. The team must be convinced that excuses are never a substitute for good service—that cheap water is too cheap when service is poor. Local management should fill the entire team with a zeal to lead the public to a better understanding of water supply and finances. The team —including the wives—should be water works partisans, willing to work and talk for improved water service, and convinced that good water is the lifeblood of the community.

The local water system manager must be well trained. If he is not trained to the point where he can appreciate the engineering, chemical, economic, financial, accounting, and legal phases of good water system organization, then he should get the training. He need not be a professional in each field, but he should know enough to realize what the professionals have to do and to give them support.

Problems and Solutions

Locally and nationally the committee objective is improved water service. There is much work to be done. Because of the nature of the industry, national water supply problems are in very large part an accumulation of local water problems. Urban population centers are growing and coming closer and closer together geographically, and they are using ever growing amounts of water per capita. Because the ultimate sources of supply cannot be increased and too many of our available supplies have been contaminated, there is, in a very real sense, a national water problem. Unless action is taken soon America will face even more critical water shortages. In case of war present shortages might well be fatal. This fact alone justifies immediate action.

By acting immediately to solve the problem of shortages locally, water utilities can contribute to business health. With the possible exception of multipurpose projects, most water problems can be solved by local action

without either federal or state aid. It has been estimated from available detailed figures that for 1958 local water supply agencies in the United States have planned and budgeted projects costing a total of more than $600,000,000. This is work now ready to be done. In addition, water projects that are needed to create adequate water systems from coast to coast in the United States and Canada, totaling billions of dollars, have been held up for years. These projects should be taken from the shelves, brought up to date, and carried forward.

There will never be a more opportune time for such action. Trained engineering personnel and labor forces are now available, and material costs, reflecting very largely union labor costs, are not apt to drop below present-day levels. Money is now readily available for worthy, well planned water works enterprises. Even in multipurpose projects the local interests must and can finance the portion created for their benefit with their own resources. Once a community is shown, by the local water works organization, that the improvements are needed and that the advantages of adequate, high-quality water service are worth the cost, the people will insist on the work and will pay the rates required.

Pollution is one of the more serious water problems confronting America today. When a stream is polluted it often becomes unfit for both domestic and industrial supply, even with treatment. This results in competition with other communities for the few remaining safe sources. New York City, for example, realizing that its own Hudson River was now so polluted that the public refused to use it as a water supply source, had to reach out to the upper Delaware and compete with New Jersey, Pennsylvania, and Delaware for water. Immediate planning and construction of better sewage disposal systems and development of better means of treating industrial wastes are essential to protect America's water supply.

Water has always been taken for granted. For years, it has been far too cheap, and some water works men boast about its cheapness. These men lack the vision to understand that good service is impossible today with rates that stem from the historic competition between the public water system and the vanished backyard well. They must come to be ashamed of the inadequate service they give, for which inadequacy they offer the excuse of inexcusable poverty.

If, on the average, water rates were increased 25–50 per cent in urban communities, it would be possible to revolutionize the entire water industry and the cost to the customer would still make water the smallest item in his budget. This can only be done through education of the public.

As a result of the shortsighted policy of keeping water cheap, the water industry has been hampered throughout its history. Poor because of unrealistic rates, systems have during the last few years shelved many improvements essential to adequate service. They have been unable to afford the engineers needed to do the detailed planning, and too poor to compete with general business for trained men.

But today conditions have changed. Today the graduates of engineering schools are finding employment harder to find than in the past, so there should now be enough available talent.

For the past 2–3 years, there has also been a shortage of available money for investment in water works enterprises. Banks and investors have

generally been in a position to pick and choose their investments, and have chosen those offering the higher yields and better coverage of debt service costs.

The water industry, in too many cases, did not have the revenues to meet such going money market demands. It could not get the capital needed to give adequate service. Today there is plenty of money available. The accumulated savings waiting for sound investments are now at or near a record high. The reserve requirements of the banks have been drastically reduced and they now have money to loan. Interest rates for prime business risks have been going down. The average yield on investments in corporate and government bonds has been declining, which means prices are higher when bonds are sold, or coupon rates are lower. On Nov. 15, 1957, the average yield was calculated at 4.51 per cent, while on Mar. 20, 1958, it was down to 3.96 per cent. Any water works enterprise that has merit and is properly managed can now get the money needed to improve service, and thereby aid the economy.

Labor for water works projects is also available now and it does not have to be taken from other industries. In fact, if immediate steps are taken to do the work that must be done, suppliers and contractors will pull back the labor they cannot now use. Insofar as labor rates are concerned, even the recent recession has not reduced them, and material costs, which very largely reflect labor costs, have also probably reached the lowest level that should be anticipated. All of these are reasons why municipalities and private water utilities should take immediate action on their planned and budgeted 1958 programs, and reasons for dusting off the shelved projects, which must be completed and even enlarged if water works systems are to be adequate.

Around all prosperous urban communities new housing developments have been going forward, and the new federal housing law is designed to stimulate more building. People are moving farther and farther out from urban centers and their present and future water systems must be planned and provided through local enterprise. Unless these new housing developments are given proper and adequate water systems from source to ultimate point of use, they cannot succeed. Right now the real estate developers in towns and cities should be contacted, extension contracts should be made with them, and materials ordered. Pumps, distribution storage tanks, pipes, fittings, and meters should be moved out of the overloaded inventories of suppliers and into the water systems where they can make possible the service needed for housing developments. Orders, now, will stimulate the manufacturers, and increase their need for labor. This will reduce unemployment and help to get the general economy on the upgrade without creating inflationary pressures. All of this can be done if local water works organizations show imagination, energy, courage, and the ability as salesmen to create public understanding and gain public support.

Trends in Water Rights Legislation

Panel Discussion

A panel discussion presented on Apr. 23, 1958, at the Annual Conference, Dallas, Tex.

Eastern Central States—*Charles H. Bechert*

A paper presented by Charles H. Bechert, Director, Div. of Water Resources, State Dept. of Conservation, Indianapolis, Ind.

FROM a study of what is being done by some of the eastern central states in regard to water rights legislation, it appears that since the discussion of the matter at the 75th Annual Conference in Chicago there has not been as much urgency to enact legislation on the subject as there was in the years immediately prior to 1955. One reason for this may be that some of the acute water shortages that existed in 1953 and 1954 have been partly alleviated by more normal rainfall in the past few years. Another may be that some of the states prefer to wait and find out how some of the newly enacted water rights legislation in other states succeeds. Some significant actions have been taken, however, by several of the 31 eastern states during the last 2–3 years.

Mississippi

With the passage of Chapter 167 of its legislative code in 1956, Mississippi became the first of the 31 eastern states to adopt the principle of prior appropriation for surface waters. The law establishes a board of water commissioners and a water engineer to determine and administer appropriation rights. This law allowed riparian owners to use water from a stream without a permit from Apr. 6, 1956, to Apr. 1, 1958, after which time the actual appropriation of surface water began. Under the law the board cannot approve the appropriation of water below the established average minimum flow, which is defined as the average of the minimum daily flow occurring during each of the 5 years in the period of the preceding 20 years. Three amendments to the Water Rights Act have been recommended to the Mississippi legislature, which is now in session. If one of these amendments is passed, persons seeking to establish their vested rights will have to apply on or before Dec. 31, 1958.

Another important water bill now before the Mississippi legislature is one requiring water well drillers to file logs of certain water wells with the State Board of Water Commissioners. Mississippi has no ground water law, and, according to the water engineer of the State Board of Water Commissioners, there are no plans to recommend control of ground water.

Tennessee

In 1955, the Tennessee legislature created a water policy commission

which in turn employed a private consulting firm to prepare a report entitled "Public Water Policy in Tennessee." This report was published in 1956, and one of its recommendations was that a state administrative organization for water resources be established. As a result of this recommendation, a law was passed in 1957 establishing within the Tennessee Department of Conservation a division which is known as the Water Resources Division. One of its duties is to continue the study of the state's water resources with a view toward the creation of a basic long-range water resources policy for the state. The water engineer of the Division of Water Resources recently informed the author that the division is making a study of water rights and expects to present recommendations for legislation to its general assembly in Jan. 1959.

Alabama

Alabama is one of the eastern central states that has no law pertaining to water rights and water control. In 1955 a bill was introduced in the Alabama legislature which provided for a study of Alabama's needs with particular reference to water usage and needed legislation. The bill was not acted upon and the author has been informed that because of the wet weather since its introduction, little interest has been shown in overall water usage and water control legislation.

Kentucky and Indiana

Kentucky passed a law as early as 1954 declaring that water in any stream, lake, or other natural body of water is a natural resource and public water and thereby subject to control and regulation for the public's welfare. The only additional water legislation passed since then is the act of this year's legislature creating a commission to study Kentucky's water problem during the next 2 years.

Indiana has followed a somewhat similar course, although the legislature in 1957 did pass a bill amending the 1955 water resources law, which, like the Kentucky law, declared the surface waters of Indiana to be public water and subject to such control and regulation as might be determined by the general assembly. The 1957 amendments broadened the original act and also provided for a continuance of the Water Resources Study Committee. The amended bill was passed, but subsequently vetoed by the governor. Recently, however, the Water Resources Study Committee has been reactivated by the State Legislative Advisory Commission. Indiana's 1951 ground water control law, with possibly a few amendments, appears to be adequate for the present.

Illinois and Ohio

Recently the Illinois State Chamber of Commerce published a mimeographed booklet relating to Illinois water rights law with recommendations as to what should be done about it, but Illinois has not thus far enacted any water rights legislation.

In 1955, the Ohio Legislative Service Commission submitted a report entitled "Water Rights in Ohio" to the 101st General Assembly of Ohio. The conclusions of that report were that an inventory of water and related resources and a survey of present and projected water use were necessary before an effective water code could be developed. As a result of this recommendation, the legislature appropriated funds for making an inventory of Ohio's water resources. This is pres-

ently being done by the Division of Water of the Ohio Department of Natural Resources. No further action has been taken to modify existing water rights law in Ohio and none is planned until the inventory is complete.

Pennsylvania

The Pennsylvania Water and Power Resources Board, which was formerly the Water Supply Commission of Pennsylvania, has the authority to issue permits to any public water supply agency desiring to acquire new water rights, or to acquire an additional quantity of water or water rights from an exising source of water supply. This authority is not new, however, and, as the author understands it, is limited to public water supplies. The State Department of Forests and Waters advises that, at the present time, revisions to the existing legislative acts are being contemplated, but the matter has not been studied sufficiently to supply information at this time. In 1956, Pennsylvania passed a law providing for the licensing of well drillers and the sealing of abandoned wells.

West Virginia

The water commission for West Virginia prepared a report entitled "A Comprehensive Water Resources Program, Including Water Rights, for West Virginia" in August 1957, but the state has taken no statutory action.

Atlantic Coast States—*Henry C. Barksdale*

A paper presented by Henry C. Barksdale, Branch Area Chief, Ground Water Branch, US Geological Survey, Arlington, Va.

In recent years, water rights legislation in the eight states along the Atlantic Coast from New Jersey to Florida has fallen into a fairly consistent pattern. In 1958 a bill has passed one house of the Delaware legislature establishing a state water resources commission; it may become law this year. In 1958 a bill may be introduced in the New Jersey legislature to expand the powers of the Division of Water Policy and Supply over water rights in that state. Also in 1958, a bill to bring ground water for irrigation within the purview of existing Maryland water rights legislation failed of passage. In 1957 a law was passed establishing a state water board in Georgia. Also in 1957, a law was passed in Florida establishing a state department of water resources. In 1955 a law was passed in North Carolina establishing a state board of water commissioners. In 1954, 1956, and 1957 a somewhat similar bill failed of passage in South Carolina.

The basic pattern which these pieces of legislation and others before them seem to take consists of three stages. *First*, a study commission is appointed, either by the governor or by the legislature, to study the situation within the state and to design laws. It is here that existing statutes in other states and various model laws are considered and adapted to the needs and legal patterns of the particular state. *Second*, legislation is passed, setting up a department, board, or commission responsible for studying the water resources of the state and administering their use in the best in-

terest of the people. All such agencies are referred to in this article as state water boards. The initial powers and responsibilities of different state water boards vary widely. *Finally,* laws are initiated and passed to increase the powers of the state water boards as the need for such action becomes apparent and as it is justified by public necessity. An alert state water board and the usual legislative processes will generally combine to keep such actions in step with the development of the state.

This process has sometimes been a long one, but progress is on the whole encouraging. In New Jersey, for example, a state water board (known by several names since its establishment) has had some measure of systematic control of water rights since 1907. The legislature has gradually increased the scope of that control as conditions have required it. New Jersey is now a leader in the control of water rights in the East. It still has special study commissions on occasion, and new legislation is proposed as the need becomes apparent. Some states that are relative newcomers in the field of water rights legislation have made more rapid strides in particular phases of law where an adequate foundation was laid in some other state, but future developments will probably be gradual.

A review of the present status of water rights legislation in the eight states indicates that all have had study commissions of one kind or another. All have some agency concerned with water resources. Five states have established state water boards (Delaware may soon become the sixth). In New Jersey, Maryland, and Florida the water boards have a considerable degree of authority to regulate water rights. In North Carolina and Georgia the water boards are now primarily investigatory, but regulatory legislation is expected to follow in due course.

Uniformly, the purpose of water rights legislation in the East has been the conservation of water resources. The various state legislatures and the water boards they have established would probably agree that conservation measures should be directed toward the maximum effective use of these valuable renewable resources, and toward avoiding abuses that reduce their size and value.

The device most commonly used in the East for controlling water rights is action upon (granting, denying, or modifying) applications for the right to use water from specific sources and for specific purposes. Public hearings with sworn testimony are usually held for each application. A most valuable subsidiary device has been the granting of time-limited water rights. This flexible system, as opposed to a system of permanent or indefinite water rights, takes account of the fact that with growth of the economy the more important uses of water may change. In a modification of this plan developed in New York and New Jersey a definite grant is made for a period of 5–10 years, with the provision that the grant may be modified or abrogated in the public interest at any time thereafter.

The success of water rights legislation everywhere depends primarily upon the intelligence, dedication, and vision of the men who administer it. The strongest law becomes ineffective if poorly administered, and, as was true of a ground water law in New Jersey, for example, skillful administra-

tion can make what seems a relatively weak law highly effective. The form of water rights legislation has been well studied, but too little attention has been paid to its administration. A series of discussions on the methods being used in the various states to administer water rights legislation would, at present, serve a valuable purpose.

North Central States—*John W. Cramer*

A paper presented by John W. Cramer, Partner, Fulton & Cramer, Lincoln, Neb.

A summary of recent water rights legislation in the states of Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota is given below. Where possible, the author has included what information he could gain from water commissioners and other state officials on their views toward existing or possible legislation.

Iowa

A new law passed in 1957 amends the existing law and declares all water, surface or ground, to be public wealth of the state and places the administration thereof in the hands of the Iowa Natural Resources Council, which has nine members. The law establishes a permit system and provides for appointment of a water commissioner and deputies by the council. The council and commissioner or deputies have authority to hold hearings, administer oaths, take testimony, subpoena witnesses, and order the taking of depositions.

The new law specifies that the only nonregulated uses of water shall be:

1. For household purposes, poultry, livestock, and domestic animals
2. Beneficial use of surface flow from rivers bordering the state or use of ground water on islands or former islands in such rivers
3. Existing beneficial uses within the territorial boundaries of municipal corporations on the effective date of the act, except certain increases in use by industrial users
4. Any other beneficial use of less than 5,000 gpd.

Permits are required for:

1. Any municipal corporation or person supplying water and increaseing its use in excess of 100,000 gpd, or 3 per cent, whichever is the greater, beyond its highest per day beneficial use prior to effective date of the act.
2. Except for nonregulated uses, any person using in excess of 5,000 gpd diverted, stored, or withdrawn from any source of supply except a municipal system or any other source specifically exempted by the act
3. Any person who diverts water or any material from the surface directly into any underground watercourse or basin, unless such diversion existed on the effective date of the act, and no waste or pollution is created
4. Self-supplied industrial users within a municipal corporation when their use exceeds by more than 3 per cent the highest per day beneficial use prior to effective date of the act.

The commissioner and council have the right to issue a permit for beneficial use in a watercourse, provided an

established average minimum flow is maintained. For this purpose, the council has the right to establish average minimum flow at any point on any watercourse. No use is authorized which will impair the effectiveness of pollution control laws of the state, and no permit shall be issued which will impair the navigability of any navigable watercourse.

R. G. Bullard, water commissioner, feels that the law will benefit public water supplies because "minimum stream flows somewhat above historic lows will be protected against consumptive withdrawals." He also feels that some amendments to aid in the administration of the law will no doubt be passed in 1959.

Kansas

Prior to 1945, Kansas had no law providing for the actual ownership of water rights. The Kansas Water Appropriation Act of 1945 was proved over the years to have several loopholes and to have created certain awkward situations which were difficult to resolve equitably. Accordingly, the 1957 legislature passed a new law making extensive amendments to the original 1945 statute. Features of the new law are that it: [1] makes virtually all water use subject to appropriation, including municipal uses; [2] recognizes the priority doctrine of "first in use, first in right"; [3] puts administration of the law under the State Board of Agriculture, which creates administrative problems and makes it difficult to resolve any conflicts between municipal, industrial, and agricultural users; [4] protects prior rights of municipal systems; [5] allows municipal systems to gain new water rights by negotiation or by exercise of the powers of eminent domain; [6] makes adequate enforcement provisions.

Possibly some administrative problems could have been avoided by placing the administration of the law under the already existing and well staffed Kansas State Water Resources Board, but, by and large, this is good legislation.

The law has recently been declared unconstitutional by a district judge and the case is now on appeal to the Kansas Supreme Court. Attorney General John Anderson, Jr., is confident that the law will be upheld by the high court. No new legislation is known to be in preparation.

Minnesota

In the last 2 years there has been no legislation that materially changes water law as it affects public water supplies, although legislation was passed creating the Minnesota Water Resources Board and amending an existing statute to define public waters subject to control by the state. Leonard N. Thompson, general manager of the Saint Paul Water Department, feels that there has been a strong tendency over the last few years to place more control power in the hands of various state departments such as the Water Resources Board and the Conservation Department; however, he believes that this has been in the public's interest overall, and says that he knows of no instance where a municipal system has been adversely affected by state regulation, old or new.

F. L. Woodward, director of environmental sanitation of the State Department of Health, believes that existing law could be improved by defining priority and giving public water supplies the highest priority. Permits

are not now required for the appropriation by municipalities of ground waters that originate within them. Woodward is concerned, however, because he feels that an effort may be made to require permits in such areas, and that it may be successful.

Missouri

There is absolutely no law in Missouri regulating the use of water or establishing or even defining water rights for either surface or ground water. A stream pollution control bill was recently passed, but this relates only to contamination of waters and does not in any way regulate their use.

Warren A. Kramer, chief of the water supply section of the Division of Public Health Engineering, reports that there has been some discussion of regulatory legislation and feels that some proposals may be made in the near future though none have crystallized yet. Both H. O. Hartung of the St. Louis County Water Company and John M. Dalton, state attorney general, report no contemplated legislation to their knowledge.

Nebraska

Nebraska has for many years controlled surface waters. Appropriations are made on the basis of priority of applications, and municipalities are required to have an appropriation to use surface waters. Water supply systems have an available remedy if their appropriations are insufficient: for municipal use, for other than industrial purposes, the use of surface water appropriated for irrigation or water power may be interfered with, provided just compensation is made to the prior appropriator. Of course, the application of this remedy would require the determination (probably by the courts) of: [1] what portion of the municipal use is industrial, and [2] what is "just compensation." Likewise, the use of water under a prior appropriation for the generation of hydroelectric power may be interfered with by a junior appropriator for irrigation if just compensation is paid to the power user.

A 1957 law requires the registration of all irrigation wells installed after Sep. 20, 1957, within 15 days after their completion, and requires that all irrigation wells drilled before Sep. 20, 1957, be registered on or before Jan. 1, 1959. Neither of these provisions applies to domestic or municipal wells. The law does, however, give preference to the use of ground water for domestic purposes over any others, and to agricultural purposes over manufacturing or industrial purposes. Here again, a finding might have to be made as to the amount of industrial water consumed in a municipal supply in order to establish the municipality's superior right to the remaining domestic water. Some Nebraska municipalities are faced with depletion of their well supplies by the drilling of irrigation wells adjacent to them.

Dan S. Jones, director of the newly created Department of Water Resources (a part of the highway department) reports that the Legislative Council Committee on Water Resources is now considering possible legislation relative to the control of ground water use. It is possible that such legislation may be introduced in the 1959 session of the legislature.

North Dakota and South Dakota

Recent legislation extends state jurisdiction to underground waters, residual waters, waters in noncontributing areas and waters from drains

(surface waters were already state controlled). The law places administration in the hands of the State Water Conservation Commission. Milo W. Hoisveen, engineer-secretary of the commission, feels that the new legislation is good because it gives the state broader authority over water supply and results in the allocation of water rights to municipalities and domestic users, and benefits the state. William Yegen, superintendent of filtration at Bismarck, feels that it is good legislation, if properly administered; otherwise, municipal systems could suffer badly, although none have so suffered to his knowledge.

Apparently no changes in the law are imminent, although the secretary of the commission believes it would be desirable to modify the law so as to give the domestic user the highest priority.

New laws for South Dakota in both 1955 and 1957 require that water rights be established for cities, designate municipal use as second highest priority, and allow municipalities to acquire rights for future use. Charles E. Carl, Director, Division of Sanitary Engineering, State Health Department, and Joe Grimes, Chief Engineer, Water Resources Commission, agree that this is good legislation because it establishes municipal rights to use water, provides for reasonable future use, and protects investments in facilities.

Assistant Attorney General E. D. Barron agrees that the legislation is good, but seems to feel that a positive enactment should be passed, making all waters public and subject to appropriation but those for domestic and stock purposes. There is some feeling that it would be desirable to have enabling legislation to provide for local sponsorship of water resource developments.

——Western and Pacific Coast States—*Roy W. Morse*——

A paper presented by Roy W. Morse, City Engr., Seattle, Wash.

Several of the eight westernmost states, in 1957, amended existing legislation relating to water resources. Wyoming's legislation is of considerable significance in the category of underground water rights.

In general it can be said that all of the western states recognize water rights as property rights. The appropriation of water for beneficial use is universally accepted, though the riparian doctrine is also sometimes recognized.

It should be said in passing that the so-called federal reservation theory, which resulted largely from the Pelton decision of the US Supreme Court, has the practical effect of limiting the total jurisdiction of the states over the waters within their several boundaries to those surface streams and underground waters that do not flow over, under, or on the border of federal lands.

In California, water right permits are issued by the State Water Rights Board upon such terms as in its judgment will best develop, conserve, and utilize, in the public interest, the water sought for appropriation. This board may consider the relative benefits derived from beneficial uses of water, including, but not limited to, use for domestic, irrigation, municipal, indus-

trial, fish and wildlife, recreational, mining, and power purposes. The California board also records and evaluates data provided by the users of ground waters, and its certification is evidence to protect the water rights of the users in the event of a future adjudication.

Oregon's legislative activity in 1957 was only very briefly concerned with water rights. There was, however, a house joint resolution that directed the State Water Resources Board to make studies preparatory to formulating a state water resources policy for the Rogue River Basin and watershed.

Montana now requires that an aerial photograph be filed with any petition for appropriation of water from an adjudicated stream.

In the author's home state of Washington there is pending a draft request for the establishment of a special, technical task force to prepare a state water policy, together with means of implementing such a policy.

Wyoming has been operating under the doctrine that appropriation for beneficial uses determines the water right. The 1957 legislature enacted an underground water law that has several significant stipulations:

[1] Any appropriator of underground water for domestic or stock use shall have a preferred right over all other users. Domestic use does not include municipal use.

[2] Any person intending to acquire the right for other beneficial uses of any underground water shall file an application for a permit before starting to drill. The date of filing the application establishes priority.

[3] The board of control, after considering information from the state engineer and others, may declare any underground water district a critical area, if the use of underground water is approaching the current recharge rate, ground water levels have declined or are declining excessively, conflicts between users are occurring or foreseeable, or waste of water is occurring or may occur.

[4] The state engineer may close critical areas to further appreciations or regulate permissible total withdrawals. Water users in critical areas may agree to any method of controlling withdrawals, and if the state engineer finds the agreement to be consistent with the intent of the act, the agreement is valid and supersedes regulations of the state engineer.

[5] Rights to underground waters are subject to the same preferences as those to surface waters.

Thus Wyoming becomes one of the first states to have set up a workable underground water law.

Southwestern States—*Albert R. Davis*

A paper presented by Albert R. Davis, Director, Water & Sewer Dept., Austin, Tex.

In reviewing the legislation of seven southwestern states, the author examined 147 acts. Most of them were of a local nature, but there were several important acts of more than local importance.

Arizona

Senate Bill No. 30, Jan. 20, 1956, relates to ground waters and provides for applications for permits to construct irrigation wells within critical ground water areas.

Arkansas

Act 81, Feb. 25, 1957, was to encourage and provide for conservation, storage, and use of surface water, prevent waste, and provide for the protection of the correlative rights of persons using water from streams or tributaries. In the event of shortage of water, a water conservation commission may be created and authorized to issue permits, prescribe rules and regulations, and provide penalties for violation.

Act 114, Feb. 25, 1957, provides the enabling authority for organization, formation, and operation of public, nonprofit, regional water distribution districts. It sets forth the procedures for organization and establishes the powers of such districts.

Colorado

Senate Bill No. 113, May 1, 1957, relates to underground water and provides controls for its production, distribution, and use. It also creates a ground water commission and provides for regulation of well drilling.

Louisiana

Act 432, Jul. 12, 1956, creates the Sabine River Authority, granting: [1] the right to use the waters and [2] water rights in the Sabine River and its tributaries. The act also provides thorough, practical, and legal means for control and coordination of the regulation of the waters of the Sabine and its tributaries.

New Mexico

House Bill No. 92, Mar. 18, 1957, provides for the forfeiture of water rights through nonuse.

House Bill No. 343, Mar. 23, 1957, provides for the forfeiture of underground water rights through nonuse.

Oklahoma

Senate Bill No. 138, May 2, 1957, establishes the Oklahoma Water Resources Board and confers on it all powers of its legal predecessor pertaining to water power, control, drainage, storage, irrigation, pollution, conservation, use, right appropriation, priorities, permits, and licenses. Senate Joint Resolution No. 41 authorizes the board to engage in a continuing study of water laws of Oklahoma and of recommended changes.

Texas

House Joint Resolution No. 3, a financial-aid constitutional amendment, was approved by a referendum, Nov. 5, 1957. It provides for the issuance and sale of bonds to create the Texas Water Development Fund, which is intended to provide financial assistance to political subdivisions of Texas in the conservation and development of water resources. The amendment also provides for an agency to administer the fund and to perform other duties prescribed by law.

House Bill No. 161, approved Jun. 6, 1957, is an enabling act for House Joint Resolution No. 3. It is intended to carry into effect the provisions of the constitutional amendment (above) creating the Texas Water Development Board, and authorizes the issuance of bonds to found the Texas Water Development Fund.

House Bill No. 145 provides that when a claim for water rights has been filed with and certified by the State Board of Water Engineers, and no part of the water has been put to beneficial use during the 10 years preceding enactment of the bill, the water is presumed to be abandoned and the rights are forfeited. Rights to unused portions of a certified claim may also be

forfeited. This law exempts municipalities that use water for domestic supply purposes and have a certified claim.

Senate Bill No. 1, Dec. 2, 1957, is a water planning act that created the Texas Water Resources Planning Division and placed it under the supervision and direction of the State Board of Water Engineers. The functions of the division are: to develop an inventory as to the quantity, quality, and location of all surface water resources of the state, to prepare and submit to the legislature a statewide report on water resources, and to make recommendations for maximum development of the water resources of the state. (This appears to be a practical approach to the problem.)

Michigan, Wisconsin, New England and New York

—*Lynn M. Miller*—

A paper presented by Lynn M. Miller, Jones, Henry & Williams, Cons. Engrs., Toledo, Ohio.

A review of trends in water rights legislation for any group of states soon impresses one with the fact that particular water problems are not universal, but local. The areas affected by the solution of a local problem may, however, be relatively large. Large metropolitan centers, such as New York City, Milwaukee, and Detroit, had their beginnings when individual water demands were quite modest. The elements of municipal prosperity, however, have necessitated rapid and continued expansion of facilities. In Milwaukee and Detroit availability has been only a matter of financial engineering, but the task in New York City has been of considerably different proportions, since it is a large area incorporating many diversified and competitive water interests.

Wisconsin and Michigan

Perhaps the greatest impetus to the study of water rights in Wisconsin and Michigan has been provided by irrigation demands in agricultural areas. Where such areas are contiguous to metropolitan areas the conflict over rights of use has been very great. The reason for much of the present turmoil in these two states lies in the lack of any actual statutory water laws. Until recently it has been possible to get along without such laws.

Both Michigan and Wisconsin have problems that demand exhaustive research and study before adequate legislation to determine the proportionate rights of municipalities, agriculture, recreation, and industry can be provided. In Wisconsin, the 1957 legislature created a water resources committee to study the problems of watershed control and water use legislation. A 31-page report entitled "Wisconsin's Law of Water Use" was presented in January 1958 and the remainder of the study is to be presented in November 1958.

A great conflict has developed in Wisconsin over the proposal made by agricultural interests to abandon the time-honored riparian-rights and public-use principles of water management and substitute the western, priority allocation philosophy. It is conceivable that this substitution of

doctrines could virtually eliminate portions of the state's famous recreational facilities and stand in the way of progress in several urban areas.

A bill was presented in the Michigan legislature this year which would have provided for the determination and maintenance of the normal flow of water in the inland lakes and streams of the state. It was the intent of this bill to provide a specific guide line within the common-law framework by distinguishing between reasonable and unreasonable use. This bill, however, did not clear the legislative committee. On the basis of investigations in Michigan, it has been stated that the solution to the demand for consumptive irrigation uses of water appears to lie in storing excess waters during periods of high precipitation and peak runoff.

New England and New York

Some problems in New York are similar in nature and complexity to those in Wisconsin, Michigan, and their eastern neighbors. Probably the most significant water rights question that has developed in the densely populated eastern states since World War II is the right of public access to streams and impounded waters for recreational purposes. In May 1956, the Rhode Island legislature approved a resolution to establish a special commission to study public rights of way to water areas of the state. This committee is still active.

In New Hampshire the abandonment of power-generating dams has led to a major problem because of the recreational use of impoundments. In some instances, recreational use and requirements have hastened their abandonment by power interests. In Massachusetts it has neither been necessary to enact new statutes nor to reallocate water rights to satisfy these developments because by the Colony Ordinance of 1641, all great ponds of over 10 acres were expressly declared to be public. There have been no recent developments of significance in the field of water rights throughout the rest of New England.

In Maine, and perhaps many other places, the favorable position of the public and the controversial position of the appropriator were epitomized by the decree in the case of *Paine* v. *Savage* (126, Maine 126), which states: "A public use must be for the general public, or some portion of it who may have occasion to use [water, and] not a use by or for particular individuals. It is not necessary that all of the public shall have occasion to use, but it is necessary that everyone, if he has occasion, shall have the right to use."

A Fresh Approach to Water Law

Abel Wolman

A paper presented on Apr. 23, 1958, at the Annual Conference, Dallas, Tex., by Abel Wolman, Prof. of San. Eng., Johns Hopkins Univ., Baltimore, Md.

THE authors of the preceding panel discussion (*1*) on trends in water law in the 48 states of this country have performed a major service to the water works profession. The summaries make abundantly clear that both the public and the technician in the water resources field have recaptured their equilibrium and have recovered from the natural hysteria engendered by drought and considerably magnified by less natural causes.

The summaries disclose that, fortunately, relatively few states have rushed into fundamental shifts from one legal principle to another. Most of the legislatures have decided wisely to take a second and even a third look at their water problems by means of less hurried review of their resources, their objectives for development, their historical and evolving problems, and the consequent impact of these upon principles and practices in law. Eventually these studies will disclose whether a basic water law change is necessary or whether the deficiencies in practice are those of plan, technology, and finance rather than of law. It may be predicted in turn that no two states will arrive at exactly parallel conclusions. Most of the states have evidently taken note of the old axiom that statute generally follows clear definition of problem. Lawmaking groups were on the verge of being stampeded in advance of delineation of problem and objective.

One is prompted in reviewing these summaries once more to look more closely at the present scene in water resources in order to discover some guide posts to future bases for legislative action. In doing so briefly, the author borrows extensively in thought and in language from his own recent exposition on "The Elements of a State Water Program" (*2*).

Basis of Water Rights Problems

The setting which prompts analysis of a state water program or its coordinate—a state water policy—has many fascinations. What is the setting that has driven so many people in recent years toward heated discussions of water use? Why does that occur during this particular time?

In more than 40 years of water problems there have been whole decades in which no one could summon up any particular interest in water policy or water programs. After all, it was felt, water is a universal commodity. It is available to everyone. It was even thought to be so cheap that it ought not to be charged for. Why is it that this attitude has suddenly changed in the last 4 or 5 years? As the nature of the change has a great

deal to do with designing the elements of a state water program, it is important to see what is involved:

First and foremost, of course, is the rise in water use throughout the entire country—not only in the eastern humid states, but in the much drier western states. Water use has increased as a consequence of the increase in population, of the general rise in the standard of living, of the development of new instrumentation, and of new gadgets and household uses for water, all of which have generally tended to push water demand upward.

Second, it is natural that in earlier years the cheaper sources of water were preempted. It was perfectly good engineering for every community in the United States to choose, other things being equal, that source which was most economical. Later, of course, throughout the entire country, the move was to more costly development; hence, there is now greater interest in what we do and why we do it in such large dollar numbers. The new demands brought about by air conditioning and increased agricultural use of water in the humid states are indications of reasons for a new emphasis. As in all other fields, a state of transition and the crystallization of competitive uses inevitably create friction. Friction in water use is now dominant in the minds of engineers, lawyers, administrators, and statesmen. If there were no competitive use for water, there would be no friction, there would be no necessity for water policy or for water programs. If the supply were unlimited, there would be no concern.

The third point is based on a misfortune—namely, that this increased demand for water of recent years ran concurrently with a cycle of dry weather. This is always a tragedy, because in dry weather we turn to a variety of conclusions and decisions, which in haste and, sometimes, in rashness lead us toward considerations in policy and in law that may not be quite as sound or quite as desirable as more time for digestion would indicate. Over the last few years, therefore, the humid states might have been called the "arid humid states." They are no longer the wet states. They had many uses of water normally more characteristic of arid states. There is plenty of water, but water in the wrong place at the wrong time. That merely calls to the attention of the lawmakers and of statesmen the fact that water is a commodity of varying availability in the humid states. Periods of extreme dryness alternate with periods of extreme wetness. In certain states, such as Kansas, a flood period in 1951—the worst in its record—moved into a dry cycle in the middle 1950's—the worst in its record. Thus, the administrator, the lawyer, the governor, and the legislator are puzzled as to what one does about a situation in such a state as Kansas, where there is too much water in the wrong place followed by too little water in any place. Does one conserve, dissipate, hold, restrict, or release?

What has happened under such conditions? There has been a resurgence of competitive requirements. A municipality wants the water out of a given river; an agricultural user has discovered that he lives not in a humid area but in an arid area, at least during these particular years; an industrialist is dependent upon the same sources of water; a flood-control individual tried to use it in a somewhat different way. These demands of competitive interest are sometimes illogical. Rarely are

they completely balanced in their emphasis on the other man's desires and uses. The groups are truly competitive in their interest. They behave like human beings. Each feels that its particular use is the dominant one, especially if it has either just discovered that use for the first time or just rediscovered it for the second or third time.

The problem of water, as the author pointed out some years ago, is one of too much, too little, and too bad. In nontechnical terms, that is the issue with which we are all concerned: too much, in respect to the flood situation; too little in respect either to drought or overuse; and too bad, in respect to stream pollution. Thomas B. Nolan, director of the US Geological Survey, recently noted that the problem was spelled out many years ago in Coleridge's *Rime of the Ancient Mariner*, when the Ancient Mariner complained: "water, water everywhere, nor any drop to drink." That is a poetic approximation of the great problem of water throughout the humid states.

The variation in rain—in place, in time, in season, and in cycles of years—is one of the things that must be borne in mind very rigidly when any legislative policy, any administrative program, is entered upon. There is an unpalatable truth in the water field—namely that there is no more water anywhere than there is. Now there are certain conjurers who have panaceas for solving water problems. Such magic has never been able to do away with the uncomfortable fact that there is no more water in any one place than there is. There is no magic by which an area that has, say, 12 in. of rainfall a year, can have a continuing water use of 20 in. a year. It just does not happen—unless, of course, water is imported, and there is nothing physically impossible about that.

What does happen is that something must be done about the variabilities in the hydrologic cycle. These variations, incidentally, are not statutory. No statute, no matter how skillfully drawn, creates water. If there is no such procedure, one is led to the unfortunate conclusion that there may be certain areas in every state that are going to be quite permanently short of water, unless—and this is conceivable also—the people there are willing to spend a rather large sum of money in order to bring water into the area. This obviously can be done if it is worth doing.

Elements of a State Program

Now what does this discussion lead to? What are the essential elements of a state water program? At the outset there must be an assumption by the state of a responsibility for water resources. It must be clearly stated that the state from this day on assumes not only a responsibility but a jurisdiction over the development of water resources. This does not imply an ownership. Such a jurisdiction is the underpinning of the elements which follow. Some of these elements are undramatic, but they are essential. Often the undramatic elements of the state water program are the only ones that supply intelligence, logic, data; and without data and without interpretation very little can be done.

What are these elements?

The first is an estimation, of a continuing nature, of the magnitude of the water resources available—that is, the collection of facts, the collection of data. The interpretation is of far more significance than the mere collection;

it means the actual use of such data as a guide in the development of the water program. Mere collection of data (many states have accumulated large libraries of data) without interpretation is a waste. The great Will Rogers, a keen observer in this field, used to say "collection of data is like the collection of garbage; after you have it you have to do something with it." We have shelves of data with little meaning to anyone unless they are interpreted—and then, of course, in turn, unless they are used.

The second element, which stems from the first, is different. With these factual data collected, what is the availability of the resource in specific areas—in North Carolina, South Carolina, Maryland, and Georgia, or elsewhere? With a continuing accumulation of information—and without it a program cannot move—some estimating, but not enough, could be done. What does that mean as to the availability of the resource? How much water is there? It is strange that in many of the sophisticated humid states there is yet very little knowledge of underground water resources. But all the facts must be known before a comprehensive program can be undertaken. These are simple bookkeeping processes. Bookkeeping in the water resources field is just as important as it is in the manufacture of nylon. Without bookkeeping, neither can function, although many states insist that there is no need to keep books in the water resources field. There could be no greater fallacy. That any organization could ever operate without carrying on its books what it is and what it sells is inconceivable. It is equally clear that any industry which says "we kept books for 5 years, now let us stop," is unlikely to survive.

The third element is an accounting process for quality. What is the quality of these water resources? The requirement is self-evident.

The fourth element of the program is an estimate of the expected use. We, as a nation, may know what we have, know where it is, know what its quality is. What, then, do we propose to do with it? It is here we run into trouble—into a rather human trouble. No engineer—and perhaps no lawyer—is omniscient. Many engineers like to see the future as far as it is discernible. The field of prophecy in water and land use is filled with mistakes. That is mainly because one cannot foresee the future completely accurately. The future has been foreseen on occasion with such accuracy that it is uncanny, but only on occasion. And one must project use as much as one can. Every state agency which has responsibility for projecting use must decide whether a particular water resource in a particular place within its state shall be used for municipal, industrial, or agricultural purposes. Such a decision will inevitably have to be made. Such a decision must remain in the hands of wise administrative agents and not be frozen into a statute. The freezing of prospective use into a statute is worse than prophecy, because it crystallizes the present without knowledge of the demands of the future.

One of the interesting features in the southern humid states implicit in every one of the initial legislative proposals was the establishment of priorities of use resting primarily upon present uses or present pressures for use. The economic progress of those states has been in the direction of industrialization. In the midst of that trend the priorities were proposed in such a way

as to weaken industrial potential—a very curious conclusion on the part of some of the code committees. Simultaneously with these proposals, the western dry states, where agricultural use is the historical base of economic development, are now under severe pressure to give way to an industrial priority for water use.

One cannot anticipate the fate of California by too many years any more than one can anticipate the fate of North Carolina by too many years. That does not mean that one must have chaos of use, it does not mean that one must have chaos of allocation; it *does* mean that one must have flexibility of allocation. A statute does not provide flexibility. The statute must provide the elementary principles of allocation, but not spell out their priorities. The administrative state agency, whether good or bad, must do that. It must be the daily local observer of the trend of development—economic and social—in any one of the humid states or anywhere else. As legislative hearings are held in various parts of every state, representatives listen, as they must, to the local requirements and demands. Every experienced legislative representative knows that listening to anybody, including an engineer, is an art; it is an art of discernment, of selection, of picking the significant from the unimportant, of differentiating between the pressure emphasis and the logic of the situation.

The fifth element of the state program—and this is the key to the problem—does not reside in the statute. It involves the means of development of the water resources. If a river in any state dries up in the summer, a piece of legislation written by the modern parallel of King Canute does not make it flow. That is an axiom that ought to be apparent no matter what was said in the law when it was passed. The river is dry. Now that means, of course, that that particular river must be impounded; it must be conserved in its wet periods for its desirable releases in dry periods. That is feasible from an engineering standpoint and, of course, from a legal standpoint. Unless that kind of development is studied by states, by municipalities, by industries, and by agriculturists, the nation will not have maximum water use, for the hydrologic cycle is inexorable. The river will not obey King Canute, no matter which legislative body says it should. It is going to be dry; it is going to be excessively wet; and it is only artificial arrangement of that resource that will provide its maximum contribution to the citizens.

The last element of the state program is perhaps the most difficult one of all. Relatively few of the humid states have provided their administrative agencies with sufficient budget or personnel to resolve a development program—relatively few—but there are some. The program for resource development by the administrative agency is one which must follow in the future as demands for water increase in relation to the availabilities.

The state development program must carry with it an evaluation in terms of economic and social values to the state. Just as there is no escape from a hydrologic cycle, there is no escape from the dollar. Every development program costs money. Every development program, whether it is financed locally, by state, or by federal government, is financed out of some form of payment locally. Again, there is no magic. The dollar controls the situation and, in a development pro-

gram, one must determine who is to pay for what. There is no lack of people who want resource development in the water field badly, who even need it badly, and who would like somebody else to pay for it. That is the human reaction. The search for someone else to pay for this painful process is eternal. The AWWA statement of policy on water resources (*3*) has shed some light on the legitimacy of benefits versus costs and on the validity of who shall pay for what.

Summary

The vital complications of water use and development do not result from technical considerations. Water can be brought into Death Valley if one has a mind to, if one has a reason for it, and if one can pay for it. The vital considerations that plague the nation are not the engineering considerations; they lie in the desires and in the competitions of the people who want water. It is a human problem. The trouble with water is that it is literally a problem of people, not a problem of engineering. The engineer will agree that anything can be built and that water can be delivered anywhere—at a price. The problem then becomes: To whom should it go? With what priorities of allocation? By what system of reimbursement will the state rise or fall?

The importance and the ingredients of a statute need a closing comment. The statute should elucidate simple, central principles in policy to aid the state agency which is to assume the administrative responsibility. The execution of that policy, in accordance with those principles, should be left to the administrative agency, largely because the administrative agency is permanent, flexible, and actively responsive to changing trends.

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Planning for Distribution System Emergencies

Panel Discussion

A panel discussion presented on Apr. 22, 1958, at the Annual Conference, Dallas, Tex.

General Principles for the Control of Water Main Breaks—*Frank E. Dolson*

A paper presented by Frank E. Dolson, Vice-Pres., Distr., St. Louis County Water Co., University City, Mo.

UNLIKE other essential utility and municipal services, a reduction in water pressure or a water outage is of immediate concern to those who are affected. Traffic jams are accepted as commonplace occurrences; storm waters backing up into houses or street intersections because of inadequacies in the drainage system may cause mild complaint; power or telephone outages are accepted with a certain degree of tolerance.

A water main failure causes an immediate reaction of those who are inconvenienced. Telephone trunk lines to the utility become clogged with customer calls requesting restoration of service. It is the utility's obligation and duty to restore service with efficiency and dispatch. To do this requires organization and planning. Quick and efficient location and repair of main breaks is one yardstick by which a utility's performance can be measured. There are others, but this is one area in which a utility can score with proper advance planning.

This discussion will deal with pipeline breaks which cause reduced pressure or a service outage, and not with small leaks, which increase the amount of water unaccounted for but do not interfere with customer service. The technique employed to locate the service outage type of break is different from the methods used to locate troublesome small leaks. Urgency is always a factor and often adverse weather and night-time working conditions are present.

Competent personnel, good equipment, proper system and valve design, and an intelligence center with radio communications are all necessary to an efficient organization for the control of water main breaks.

Personnel

Competent and well trained personnel is the most important single requisite for quick location and speedy repair of major pipeline breaks. Foremen and supervisors who are to have responsibility for emergency system repairs should be carefully chosen. Once selected they should receive adequate instruction and training in the fundamentals of locating main breaks. Such personnel should have knowledge of the physical piping system and all river, creek, and other underwater crossings. Knowing the size and loca-

tion of important pipelines is also helpful.

The field foreman should be trained to count and record the number of turns required to close or open each valve operated. He should also observe significant detail, such as unusual flow in creeks and sewers or exceptionally noisy valve closures. This information should be reported to the dispatching center.

When a break is difficult to locate, the engineer or supervisor at the dispatching or intelligence center is the key person in the hunt. He must be familiar with the physical characteristics of the system and, in addition, know its hydraulic characteristics. All information from field personnel and customers should be transmitted to him for correlation and study. He should be informed of significant changes in pumping rates or the rate at which system storage is being depleted.

Calls from customers reporting either a service outage or materially reduced pressures are extremely significant. So, too, are reports of pressure at critical gaging stations or of pressure changes caused by valve closures. Conversion of pressure readings into pressure gradients and the plotting of this information by qualified persons on a comprehensive system drawing often narrows the search to a small and manageable area.

Equipment

Emergency service vehicles should be fully equipped with tools and auxiliary equipment necessary to cope with the situation at hand. Basic equipment should include hand- or power-operated valve keys, auxiliary generators for emergency lighting, pressure gages with proper adapters for fire hydrants and hose bibs, sensitive listening devices, and similar items. Probably the most important single item of equipment, which every emergency vehicle should have, is a sectional drawing of the system on which the system piping is diagrammatically shown with each valve indicated and referenced so that it can be quickly found.

Mobile radio equipment, although not indispensable, almost falls in that category. By its use, immediate reports of valve closures, pressure readings, and significant physical observations can be transmitted to the dispatcher. Such information can be quickly correlated by the dispatcher and conclusions often may be reached which narrow the search to definitive areas.

Another item of great value is telemetering equipment for the transmission of system pressure at strategic locations to the dispatching center. This information, if converted to pressure gradients, plotted, and then properly interpreted will immediately indicate the general area of the trouble. Often, by comparing the drop in pressure gradient at one location with that of another and relating this data to the hydraulic characteristics of the system, the severity and location of the trouble may be estimated.

In those systems where telemetering has not been installed pressure-recording gages, properly located, serve the same purpose, but not without some delay. In this situation, a survey of the stations should be made by one or more employees and readings before and after the occurrence should be relayed to the dispatching office. In those cities where permanent gage stations have been established in fire department buildings, police stations, or the like, a survey of pressures can be quickly made by telephone.

System Design and Valves

Another element of advance planning includes proper system design and proper valve maintenance practices. Valves should be installed in such a manner that trouble spots may be quickly isolated without too many valve closures. Important pipelines at critical river or other water crossings should be valved on either side. When economically feasible it is often desirable to make such crossings by installing dual pipes of equivalent capacity. If this is done service may be restored should a failure occur on one of the pipelines merely by closing two valves. In many situations, on important supply mains, the use of rotating-plug or similar types of valves, which can be operated by one man, may be justified. In extremely important pipelines, power-operated valves with either local or remote control may be economically feasible.

If valving is to serve the purpose for which it was installed, good preventive maintenance practices must be followed. Valves on supply and arterial mains should be operated at stated intervals. Turns required to close the valve should be counted and compared with those recorded at the time of original installation. Access valve boxes should be positioned over the operating nut and raised, if necessary, to be flush with the ground or road surface.

General Principles

The procedure to be followed in the location of a major main break cannot be reduced to a pat formula. If it could, there would be no problem. Advance planning is necessary for efficiency. Certain techniques and principles may also be used to advantage:

1. All information should be funneled into a single control center for recording and analysis.
2. All possible information should be obtained from customers who call to report trouble. The name and address of the person calling should always be ascertained. Often, it is helpful to determine if the person calling is completely without service, has service on the first but not second floor, or perhaps merely has a noticeable reduction in pressure.
3. Field reports of pressure at critical spots should be obtained as quickly as possible. Such information should immediately be reported to the control center.
4. If valve closures are necessary the effect of such closures on pressure adjacent to the valve and at other locations nearby should be observed and reported.
5. Generally, only one valve should be closed at a time. Only at the direction of the dispatcher should simultaneous valve closures be made.
6. Vulnerable parts of the system, such as river crossings, should be subject to inspection and testing, if located in the general vicinity of the trouble.
7. A map of the system should be available in the dispatcher's office so that all incoming information can be recorded on it.

Perhaps the time will come when telemetered hydraulic data from the system may be fed directly into digital computing machines or network analyzers which, in turn, would calculate and print on a tape the exact location of the failure. Until that remote time arrives the prosaic methods now being used, together with the employment of good common sense, must prevail.

Controlling Water Main Breaks at Atlanta

Roy Ruggles

A paper presented by Roy Ruggles, Chief Engr. of Construction, Atlanta Water Works, Atlanta, Ga.

Since the beginning of the Atlanta Water Works in the early 1870's there has been continued progress and advance planning to provide an ample supply of pure water for present and future generations. Little progress was made, however, in training personnel and improving equipment. The inadequacy of this approach became very apparent several years ago when a 20-in. plug blew off a tee on a 30-in. main. All was confusion as no one had taken the time to train the personnel or provide adequate, modern equipment in advance for such an emergency. Finally, the valves were located; then began the slow and laborious task of closing them by manpower to isolate the broken section. All this lost motion caused an unnecessary delay in restoring normal service.

This occasion brought vividly to the utility management's attention the need for new methods both in training emergency crews and in providing mechanical valve operators and other modern equipment for efficiently coping with breaks of all kinds.

Upon a study of this and other breaks the problem resolved itself into five steps:

1. Locating the break (if it has been detected by drop in gage pressure rather than by someone's reporting it)
2. Reaching the break without delay
3. Isolating the break promptly
4. Repairing the break swiftly
5. Resuming service with a minimum of inconvenience to the public.

General Approach

To accomplish these five objectives, advance planning is essential, and this includes clear, concise records instantly available. For this purpose, the Atlanta water utility uses 9×14-in. cards on which several street intersections are plotted and all essential data are clearly indicated. These cards are cross-indexed by street names. In addition to these regular records, bound copies of drawings, giving complete information on the location and control of each feeder main, are furnished to all supervisors.

Another important factor is to maintain a crew whose sole duty is to service and repair valves so that their proper operating condition may be assured.

Each supervisor's truck and all emergency trucks are equipped with two-way, mobile, repeater-type radios which permit constant contact with the central dispatcher's office and from one car to another. The dispatcher's office is the nerve center of the system and has radio connections with all pumping stations, the purification division, and the business office so that communication is maintained even if the telephones are out of service. The dispatcher's office, which operates 24 hr a day, receives data on pressures and tank water levels from 40 stations throughout the 2,000-mi system by direct telephone lines, so that any unusual changes in the system can be instantly detected. Direct contact is also maintained with the fire department.

All supervisory personnel are on 24-hr call. Each is furnished with a pickup truck equipped with a mechanical valve operator, a portable light plant, all necessary tools, and a two-way radio. They also carry a directory of foremen, which includes their telephone numbers. Each crew foreman has a list bearing the names and telephone numbers of laborers selected for their willingness, ability, and accessibility. To promote efficiency and morale of crews, provision is made for nourishing, hot food for those who work all night on emergency repairs.

A running inventory is kept of all emergency material, such as sleeves, pipe, and other items. These are never allowed to get below a predetermined minimum.

Data on broken mains when the cause is not mechanical are reported to the manufacturer, who usually requests specimens for the purpose of testing to determine if the material is faulty. This research on pipe and other materials has been beneficial both to the manufacturer and to the water utility. The methods used on each break are evaluated and weak points are noted in order that they may be eliminated in future breaks.

Procedure

The best method in repairing breaks is to organize, deputize, and supervise. The maintenance team should be so organized that each member is thoroughly familiar with and trained in the performance of his duties. This can be accomplished by in-service training and demonstrations on rainy days. Each worker should be assigned his definite responsibility so that there will be no overlapping of authority or of duties. When all else is done, there is no substitute for constant and efficient supervision to obtain the best results from each member of the team.

The pumping stations, filter plant, police and fire departments, and, if possible, affected customers should be notified when a break occurs. Water can be supplied in large milk cans to customers in the immediate vicinity of the break where there may be urgent need.

An effort should be made to anticipate and plan for handling all problems that might arise in connection with a main break. The cooperation of the press, radio, and television stations should be enlisted as they can be of great assistance in maintaining good public relations.

Equipment should be kept clean and in good operating condition by frequent, scheduled tests. This equipment usually includes: a crane of sufficient capacity to handle the heaviest anticipated load, one or more light plants, floodlights on adjustable stands, air compressors, pumps of large capacity, pipe-cutting machinery, a lead furnace (preferably gas-fired), barricades with flashers, traffic cones, hand and air tools, acetylene torches and related equipment, a pipe truck, a construction truck with a valve operator, and safety clothing. For cleaning up after the break is repaired a front end loader and dump trucks are needed.

A very important piece of equipment used by the Atlanta water utility is an emergency trailer which also functions as a field office. This trailer has duplicate a-c generators, portable floodlights, a 2-way radio, valve records, a table for drawing and laying out prints, tools, and first aid equipment, including a stretcher. It also contains a gas stove, cooking utensils, and a supply of canned foods.

Preventing Water Main Breaks at Indianapolis

Howard W. Niemeyer

A paper presented by Howard W. Niemeyer, Supt. of Distr., Indianapolis Water Co., Indianapolis, Ind.

A long-standing recognition by the Indianapolis Water Co. of its responsibility to provide continuity of service for its customers is clearly reflected in the design and construction of its distribution facilities. Every effort has been made to avoid failures of service. The plants and distribution system have been built with sound engineering, good safety factors, and the best construction know-how available. At the same time, the possibilities of failure have been recognized by designing the facilities to minimize its effect. The foresight used in planning the basic elements of service has been well rewarded, for the company's record of distribution reliability is extremely good, especially for a utility operating in a northern state where cold weather multiplies its operating problems.

Distribution System

The company's system has an initial advantage in that it is served by two primary pumping stations using separate sources of supply. The distribution system is then divided into three primary pressure districts. The mains are completely joined between districts with pressure separation made by valving along the adjoining borders. This allows temporary adjustments in divisions or the transfer of supply from one area to another if needed.

The low-level pumping station, which supplies approximately 60 per cent of the city's requirements, has six transmission mains, ranging in size from 20 to 36 in., radiating out into the area. All of these mains are cross-connected and so valved that any one of them can be removed from service without serious distribution effects. The low-level area is supplied entirely by direct pumpage with finished water storage provided on the suction side of the pumps. A margin of safety has been provided by the installation of emergency standby pumps at two locations, both having finished water suction and discharging into the system separately and distant from the central station.

The high-level pumping station, which supplies the remainder of the city's requirements, discharges different pressures to two separate zones. This station also has six transmission mains, ranging in size from 20 to 24 in., radiating from its pumps, three to each zone. These feeder mains are likewise cross-connected and valved so as to permit outage of any one of them. Each of the high-level systems has pressure storage which provides a limited degree of emergency standby.

The distribution system is well gridironed, all sections having multiple feeds so that outage of one feeder into an area does not disrupt service to it. The only exception to this is in newly developed fringe areas where growth has not been sufficient to warrant completion of planned distribution mains. The entire system is constructed of proved materials with designed strengths that have always exceeded service requirements. An outside agency inspects all purchases of pipe and fittings at the foundry to reduce the possibilities of defective materials being installed in the system.

Pipes have been installed at adequate depths with the best laying practices known. Careful analyses of operating experiences are regularly made to isolate causes for unsatisfactory results so that corrective steps can be specified.

The system is well valved so as to minimize the extent of service interruptions due to a main outage. Early in its operation the company recognized the advantages of a standardized direction of valve operation and adopted a common turning direction for its valves. As a result, only eighteen of about 11,000 valves in the system are nonstandard and these are clearly identified on all maps and records.

Precautionary Measures

Several years ago the time required to control a major break in a 36-in. transmission main was increased considerably when water from the break flooded the area over the valves needed to shut out the line. As a result of this experience, all the valves in the grounds of each station were surveyed and their access levels, where necessary, were elevated above any flooding that was considered possible. At the same time, extensions were installed on valve-operating nuts because of the difficulty that had been experienced in affixing valve keys to the operating nuts when they were submerged under a considerable depth of water. This break also proved that bypass valves were of no value in balancing pressure for the closure of large gate valves against a major break. All bypass valves in the system, which formerly had been kept open, are now maintained in a closed position to save shut-out time in the control of emergencies.

Stream crossings, except for small-size mains, have been valved on each side for ready control of failures. A card record is maintained of each crossing, from ditches to rivers, as a control system for regular inspections which are made to insure the adequacy of their cover and protection. Stream crossings would be surveyed immediately if a suspected major break had not given surface indication. This card record would be most useful in quickly organizing and dispatching personnel for such emergency inspections.

The importance of distribution system maps and records has long been recognized. In addition to the mapped and measured location of valves, a physical record card of each one is maintained in the dispatching office for ready reference as to make, size, age, operating turns, and test performance.

Years ago the company initiated an annual testing program for the purpose of maintaining all valves in a ready-to-serve condition. The program is primarily intended to seek out malfunctioning valves and valve housings which are clogged or have been submerged under street maintenance and improvement work; it also serves as a rehearsal for emergency operations. Through the repetitive operation of all valves the personnel become quite familiar with the system, the location of valves, and with their operating characteristics. Such experience is invaluable when an emergency does arise.

The distribution system is surveyed for nonsurfacing leaks once each year, as a waste-control program. The surveys can also be considered as another phase of the company's control of distribution emergencies. Leaks which are undetected continue to grow in size and the resulting cavitation around the pipe, or other disturbances to the pipes' bedding, can lead to a major failure. The company, there-

fore, considers it good insurance to find all leaks, however small, as they develop, as one of them may be the beginning of a future emergency.

The company currently uses two truck-mounted mechanical valve operators. The valve-operating trucks carry leak and pipe locators, pressure gages, and miscellaneous hand tools necessary to perform all types of tests and checks of the system. These units are immediately dispatched to the location of any indicated difficulty to investigate the nature and scope of the trouble. Their reports are relayed back to headquarters for the information of the customer inquiry division and for the assembly of any required maintenance force. The valve-operating crew then proceeds with main shutoffs, if required, and the notification of affected customers.

To expedite the handling of all emergencies, the valve-operating and maintenance trucks are equipped with mobile phone service provided by the telephone company. This particular type of radio service has an advantage in that it can be interconnected with the regular wired phone system to provide direct communications between key personnel at the office or at their home and any unit out in the system. The company also maintains two unlisted trunk lines into its operations center for emergency use in case a major deviation in service should flood the switchboard with customer calls. Recently, two automatic phone-answering units were installed that are used when the switchboard is closed. One of these units carries a standard busy message for calls that overflow the lines normally answered by a night dispatcher. The other unit carries a general emergency message for temporary use until the cause of emergency can be established and a more informative message placed in the machine.

Standard procedure is outlined in a company practice manual for the notification of key personnel of emergency situations. This procedure includes notification of the publicity director who is to prepare messages for local radio and television stations and newspapers.

Adequate stocks of repair materials in all sizes and types are maintained. Maintenance trucks are all of special construction, having compartment bodies designed to carry all the power tools, pumps, hand tools, repair materials, and supplies required for the maintenance of the distribution system. The trucks are equipped with 105-cu ft compressors driven by the truck engines and a half-ton hydraulic hoist. All maintenance units are refueled and restocked each evening so that they are always ready for immediate dispatching to any type of job, day or night.

Summary

The Indianapolis Water Co.'s experience with main failures has not been unfavorable. The majority of breaks that have occurred have been caused by cold. Eighty per cent of all pipe failures have been recorded in the period of November through February, and, more specifically, at times when water temperatures were approaching 32°F. With this knowledge, the organization is alerted with the occurrence of each cold wave. Anticipating a rash of main breaks during a severe cold wave during the winter of 1957–58, the company raised water temperature in the distribution system 5–7°F by mixing well water with its surface supply. Only one pipe break occurred, in a 6-in. dead-end main during 3

weeks of severe cold, at the time well water was being used. From past experience, it could be assumed that the raising of temperatures avoided many pipe failures, with their resulting emergencies, that might have occurred otherwise.

The company has avoided "putting all of its eggs in one basket" in designing its distribution facilities. It has provided standby facilities and alternate means of maintaining service with minimum limitations if an emergency situation does arise. It has made every effort to avoid emergencies by securing a well-constructed system and then having it maintained ready for any situation that might develop.

Locating and Repairing Water Main Breaks at Philadelphia—*Samuel S. Baxter*

A paper presented by Samuel S. Baxter, Comr. & Chief Engr., Water Dept., Philadelphia, Pa.

The overall approach to an emergency organization for control of water main breaks should be to expect the best and be prepared for the worst. Every utility is faced with the possibility of serious breakdowns in its distribution system. It is good management to do everything possible to eliminate "out of service time" to customers, and damage to the plant or to private property. When emergencies do occur, prearranged plans should be available to restore service as promptly as possible.

The eastern part of the United States had an unusually heavy snowstorm in March 1958 which did tremendous damage to electric power and telephone lines. These industries threw all possible men into the breach, bringing assistance from other companies from hundreds of miles away. In the water industry there have not been very many opportunities for mutual aid, although plans have been set up in some states for this type of aid in case of enemy attack. In most cases, damage to water installations, and particularly the distribution lines, is confined to individual cases which can be handled locally.

The distribution system in Philadelphia has been built up over a period of 158 years, and some of the pipes in use are 138 years old. The system extends through busy streets, large sections of undeveloped ground, and a large park system, and across fairly deep stream valleys. It obtains water from four raw water stations and five filter plants, and contains ten additional pumping stations and several reservoirs. Although most of the system is interconnected in some way, there are twelve separate distribution districts. The system has approximately 36 mi of 24-in. pipe, 59 mi of 30-in. pipe, 28 mi of 36-in. pipe, 75 mi of 48-in. pipe, 11 mi of 60-in. pipe, and 4 mi of 93-in. pipe.

Small Breaks

One way in which a water utility is judged is how promptly and efficiently it restores service when a break occurs. The importance of prompt repair work on small main breaks should not be minimized. They may involve only a comparatively few customers in each instance, but when a city like Philadelphia has more than 500 such breaks

in one year a large number of persons are affected and pass judgment on the water utility in light of the way in which this situation is handled.

For a small main break, the Philadelphia Water Dept. considers it important that some representative of the department appear on the scene as promptly as possible after a report is made of a leak or break. If the main is a small one, this report comes in the form of a call from the police, another utility, or from individual customers who either observe the break or lose water service. Night or day, the department tries to have someone at the scene of the break within 30 min. During normal working hours, it is generally the nearest inspector to the job or the nearest work crew in the neighborhood; at night or on weekends emergency crews are on duty.

For this work, the department's 83 radio-equipped cars and trucks are of inestimable value. The man or crew sent to the scene tries to evaluate the situation. If the break is on the individual customer's line, for which the customer is responsible, the inspector serves notice. If necessary, he may try to shut off the water if the break is inside the curb stop. If a shutdown of the main is indicated, an emergency crew is called to perform this work. This is followed by the dispatch of a repair crew as promptly as possible.

One important thing which is continually impressed upon the inspector, the emergency crew, the dispatcher, the repair crew, and the supervisors at all levels is that service to the customer comes first. No main break which deprives customers of water is allowed to remain unrepaired overnight, unless some other means of providing water, such as high lining, is arranged. Wherever possible the department tries to follow the usual practice in the industry of notifying people to run off water before the shutoff is made.

This work is not spectacular and there are no special gadgets, except that the department tries to use the most modern methods possible in locating and repairing these small leaks.

Large Breaks

Breaks on the larger mains are more spectacular, and usually require more heroic action. They necessitate planning before the event, the best possible means of locating the scene of the break and of isolating the damaged section, and modern equipment and methods of repair.

The first step in handling emergency work is to try to minimize the number of actual breaks. Although blowouts do occur, it is often the case that small leaks become large breaks. The department, therefore, conducts a continuing program of water waste surveys. These surveys not only locate small leaks which can be repaired before trouble occurs but also cause the department to operate many valves, and this experience is helpful both for the employees and in discovering faulty valves. Another byproduct of this operation, which is helpful in other respects, is that the department obtains C coefficient factors for most of its large mains.

The second step requires an organization that is alert and well-informed about the distribution system. It is encouraged and directed to go into action whenever breaks or leaks are suspected and to take whatever action is necessary to find and repair the broken main. The department makes every attempt possible to instill this idea into everybody from the solitary dispatcher, who sits on duty in the

middle of the night, up to the superintendent of the distribution division and the other executives in the department. As part of their work many of these men have had past experience on other breaks and this is of real help. In addition, they are encouraged to study all parts of the system to determine beforehand what to do if breaks occur at various points in the system.

The third step involves the network analyzer, which has been in constant use in the department for about 3 years. This analyzer is used not only in the design of pipelines for new areas of the city but has made, and is making, many studies of the existing distribution system. (Before any of these studies are made, field data are obtained, including the C coefficient.) The setting up of problems on this machine gives additional information, not only to the designers, but to the operators of the system. Since the analyzer has been in use, no problems have arisen in which leaks and breaks were difficult to locate. If such a problem does arise, however, and other means of location failed, it would be possible from data which are available, plus emergency pressure and flow readings in the general area, to set up an area on the machine and determine with reasonable accuracy the location of the break. Some equipment of this type is available and other equipment might be developed.

Load Control Center

A fourth step is one which has been under consideration for 2 years, and which the Philadelphia Water Dept. hopes is shortly to become a reality. Bids for the necessary equipment for a new load control center have been advertised. Although this equipment will be put to daily use in the operation and control of the entire system it will be of real value in determining and locating breaks in large water mains which may not be quickly detected. The load control center will provide an efficient means of controlling the pumping, purification, and distribution of water in Philadelphia. It will bring in one central point, controlled by a load dispatcher, information from 92 different locations and operations throughout the city. The information will include such varied items as output from individual pumps in pumping stations, total flow from individual stations, river elevations, elevations in various sedimentation basins, filtered water basins, reservoirs and storage tanks, pump rates, high-pressure fire station output, and pressures at many key points in the distribution system.

This information will be transmitted in the first instance over land lines to eight substations, and from there it will be transmitted by microwave to the control center. By means of an analog-to-digital computer, full information for each station will be printed at the approximate rate of one station per second. Minimum and maximum limits for each operation can be preset in the machine and for readings which are outside these limits a bell will ring, a light will flash, and the information will be printed in red ink.

In addition to the reporting value of the equipment, the first installation will include four supervisory control stations by which the operator at the control center can control pumping operations at four different stations. After a trial period it is planned to add many more of these supervisory control units to the system.

The prime purpose of this equipment, of course, is to handle day-by-

day operations. Its value in locating breaks should also be very great. The operator should be able to tell by means of pressure drops throughout the system or by actions at the pumping or filter stations that some unusual use or waste of water is involved. An examination of the various locations should provide reasonably good information concerning the location of the break. When full supervisory control is installed it will be possible to take corrective action at once.

The printed information will be given automatically at prearranged times, such as every 30 min, but the operator is able at any time to obtain a reading on all stations simply by pressing a button. In addition, there will be instantaneous notice of all stations which are outside the maximum and minimum limits.

Special Problems

When the large 48-in. main in Broad Street, Philadelphia, breaks, which it does about once every 3 years, the department does not need special equipment to learn about it. It is so close to the surface that it blows paving all over this large street and creates a small flood. Other breaks are not so easy to locate. Several large water mains cross the Wissahickon Valley, which is a comparatively deep ravine through park land. A break in one of these lines, such as occurred in April 1958, may not be seen by anyone and the first intimation may come from customers calling in, complaining of pressure drops. In the April break, after receiving several of these calls and waiting for 15 min, the dispatcher on duty was able to pinpoint the approximate location and dispatch an emergency crew, which had no trouble in finding the break.

When breaks occur, there should be full public dissemination of information on what has happened, what is being done, and an estimate of when service will be restored. This can be accomplished if good relations exist between the water department and the newspapers, radio, and television. Such relations must be earned and established beforehand.

Alternative Sources of Power for Water Utility Pumping Stations

Edward Farmer

A paper presented on Apr. 22, 1958, at the Annual Conference, Dallas, Tex., by Edward Farmer, Prin. Engr., Black & Veatch, Kansas City, Mo.

IN this paper the reliability of pumping stations operated by electric power and the provision of alternative sources for emergencies are discussed without direct consideration of costs or other factors affecting the selection of pumping equipment and the power to drive it. A major portion of this discussion refers to possible outages and their consequences. Before proceeding, it is essential to state that the more pessimistic remarks concern possible emergencies, and there is no intention, or reason, to cast doubt on the reliability of electric-power service to water utility pumping stations. The relative economy, simplicity, and reliability of electric power under most conditions are recognized and generally accepted. Electric-power service has become so dependable, in fact, that undue risks of interrupted water service are probably taken in many instances because of continued reliance on very favorable operating records. The risks may also be taken because of a failure to recognize possible hazards, or because of a reluctance to spend money for the facilities necessary to provide a high degree of security against emergencies. Even though electric service may be excellent and dependable for many years in an individual water utility, the possibility of rare and scattered interruptions should not be ignored. Power service interruptions occur without warning, and reasonable protection should be provided in all systems to assure continued water service during foreseeable emergencies. On the other hand, a recent power failure, or the widespread publicity given such an occurrence, should not stampede the water system management into extravagant expenditures unless they are justified by a sound analysis of the probability of future emergencies.

Although this discussion is limited to power for pumping stations, the hazards to reliable service are often as great or greater in other elements of water systems. The overall planning should provide equal reliability throughout the system, particularly in supply works, treatment facilities, station piping, control, transmission mains, valving, and storage, with allowances for the consequences of an outage in any of the component parts of the system.

Systems supplied by gravity are not usually concerned wih pumping station problems, but expansion of their service areas may require pumping to supply customers located above the limits of the gravity system. In some instances water has been pumped downhill in order to increase the output of

long gravity supply lines. Washington, D.C., has a system that was originally supplied by gravity but now requires pumping to six service areas above the original gravity system. The original gravity system is also aided by pumping during peak periods. All pumping at Washington, including that of a supplemental raw-water supply, is now done with electric power. Extreme reliability is provided by multiple power sources, multiple pumping stations, substantial elevated storage, and ample interconnections between service areas.

Trends in Pumping Installations

In all major cities, and in most smaller ones, that had water systems at the turn of the century, pumping operations were powered by steam. Generally, a single station having both raw- and treated-water pumping equipment supplied the entire system. If more than one station was involved, the number of stations was held to a minimum because of the high initial cost, the relatively large number of operating personnel required, and the site limitations imposed by coal delivery and storage.

During the earlier developments in water systems, the public was not accustomed to, or entirely dependent on, water service from a central system. Interruptions of service were more or less commonplace and, if not too frequent or prolonged, outages were tolerated in preference to the additional cost of improving the situation. The earlier systems generally supplied the compact, relatively small area of the city, and service to the suburbs or fringes was given secondary consideration. As the system developed, major attention was devoted to fire protection. The fire protection feature, or the lack of it, initiated or hastened many of the improvements designed principally to insure reliable and adequate service.

With the development of dependable steam pumping equipment, the continuity of service was greatly improved, particularly when distribution system storage was added and supplemental transmission mains were installed to keep pace with urban growth. Interruptions in service became more and more infrequent and the public became accustomed to expecting water to flow at the turn of the tap, day or night.

The rapid strides made in the generation and distribution of electric power during the past 30–40 years have steadily increased its availability and dependability. The simultaneous development of dependable and efficient centrifugal pumps has resulted in compact and relatively low-cost pumping units that are simple to operate. Therefore, numerous pumping stations have converted to electric power or added units driven by electric motors to supplement overloaded steam stations. During the same period, internal-combustion engines also appeared, and for a while there was considerable doubt, confusion, and difference of opinion involved in the selection of power for pumping stations. In recent years, however, a definite trend has been established, and electric motors are taking over most of the nation's water utility pumping operations.

Since the middle 1930's, the exodus from compact urban areas to expansive suburban areas has resulted in many almost insurmountable problems for many cities. The people moving to the outlying areas want complete separation from the core city in most matters, particularly in paying taxes, but at the same time they want many of the comforts of home, and one of the principal

items they insist upon is city-type water service, at city rates. Many municipal or privately owned systems that formerly served relatively compact communities have extended their service to metropolitan areas including other political subdivisions, and are servicing areas double or several times the size of those served only a few years ago. It also seems that most of the suburban developments are taking place in areas on high ground and at locations remote from the water supply, treatment plant, and pumping facilities.

At first the mains extended to suburban or rural areas were generally small, often furnishing water only for domestic use—and even that service was erratic. Many systems that had been supplied by a single or a relatively small number of pumping stations were forced to add numerous booster and repumping installations to serve the outlying customers, and, with few exceptions, the pumps in these outlying stations were electrically operated. In many instances, particularly where the water utility operations were on a hand-to-mouth financial basis, the outlying stations consisted of marginal installations with the least electrical protective equipment possible. Often they used overloaded electric power lines and were subject to outages during windstorms and electrical disturbances, or surprisingly frequently as a result of collisions of automobiles with the poles.

Concurrently with these developments, particularly during and following World War II, much of the reserve capacity of installations made prior to 1930 was exhausted, and expansion of entire water supply facilities was required in practically all systems throughout the country. Not only were most systems faced with the necessity of expansion, but many of them also had to replace steam-driven pumping equipment that was nearing the end of its useful life. The rising costs of labor, fuel, replacement parts, and new equipment made it imperative to compare the economic merits of steam and electric power, even where the steam machinery had considerable remaining useful life.

For these and other reasons, most water works systems are, or soon will be, almost entirely dependent upon electric power. Furthermore, most systems include outlying booster stations that are automatically or remotely controlled. In a number of systems serving metropolitan areas, these outlying, and often unattended, stations supply thousands of consumers and are generally dependent on electric power and telephone circuit controls. With the trend toward complete or increasing dependence on electric power, the development of widespread systems with numerous pumping stations, and the increasing dependence of large, constantly growing areas on secondary stations, the problem of overall reliability should be periodically reviewed to insure the most dependable service practicable under changing conditions. The reliability of service is frequently dependent on the telephone system as well as on the power system. The power sources for most major stations have been planned to provide practically infallible service. If not, they should be. Sometimes, however, continued service has been dependent to a great extent on luck. Eventually, luck will fail and so will the water supply.

Reliability

Reliability is a difficult term to define. It has many meanings, and can

be given wide interpretations. In water service, as in all other matters, the term is relative and varying degrees of reliability must be considered. The truly reliable system would be one in which service could be maintained during all demand periods under any imaginable condition. This ideal is unattainable, however, when the threat of big bombs, big strikes, and other possible calamities exists. The more tangible but extremely erratic attacks of snow, ice, and floods, combined with the uncertain human element, make the removal of all risks impossible. Catastrophes do happen and, although it is impossible to anticipate them or to provide for all imaginable contingencies, each step in an improvement or expansion program should provide greater dependability and reduce the adverse effects of "imaginable contingencies" to a minimum.

A practical aim is to be able to maintain near-normal or minimum service during any emergency that could arise, even at infrequent intervals, from conditions that might conceivably be encountered within the system under consideration.

A minimum or temporary goal for submarginal setups would be the ability to maintain near-normal service during emergencies that may be expected at frequent intervals, and some limited service for more essential purposes during infrequent, but probable, emergencies. A system with this sort of reliability, or lack of it, should strive for definite improvements as rapidly as possible.

When considering the reliability of electrically operated pumping stations for maintaining continuous service, it is assumed that the water is available, that the station has adequate pumping capacity, and that the transmission and distribution mains are capable of delivering the water to all users in the quantities required. With these assumptions, the reliability of service is dependent upon two major factors: [1] the on-site and internal electrical facilities at the station; and [2] the power supply to the station site.

It is probable that far more outages and interruptions in pumping operations are caused by the internal or on-site electrical facilities than by failure of the power supply to the station site. In pumping stations where reserve pumping and electrical facilities are lacking, or where the proper protective devices and provisions for isolation of defective equipment are absent or poorly designed, there is a serious hazard of prolonged outage of the entire station. It is possible, practical, and financially feasible to provide a high degree of reliability within the station and at the site if sound experience and sufficient funds are utilized in the design, construction, and operation of the facilities. In well designed and controlled stations, pumping outages caused by internal or on-site electrical disturbances will be confined generally to partial or momentary interruptions. Complete shutdowns will be extremely rare, and generally of short duration—probably no more than a very few minutes at attended and remotely controlled stations and no more than an hour or so following discovery of an outage at isolated or automatic stations. Therefore, the principal consideration for alternative sources of power is the reliability of the power lines and of related facilities between the power generators and the pumping stations.

Complete dependence on any one element in a water system carries some degree of hazard, and complete dependence on a single power source must be considered as one of the greater risks. The degree of the hazard should be evaluated, however, and the probable duration and consequences of power outages, the effects of pressure reductions or water outages of varying duration, the cost of duplicating or supplementing the electric power source, the possibility and desirability of looped transmission mains from other stations, and the effect or desirability of elevated storage should all be considered.

Outage Consequences

In systems or parts of systems dependent on a single station, and without storage floating on the distribution system, a complete outage of more than a few minutes' duration could result in serious health hazards and, if coincidental with a fire, in increased fire losses. Momentary outages might also create surges on the water transmission lines which could cause pipeline breaks and service interruptions far more serious than the power outage itself. In general, however, the hazards from momentary outages, both electrical and hydraulic, can be eliminated or minimized by proper design and control of the on-site facilities.

The consequences of power outages in any one system must be considered on the basis of its own particular circumstances. Most generalizations are subject to challenge and to exceptions. In a large, direct-pressure system supplied with electric power over long transmission lines, the problem is entirely different from that of a small system with substantial elevated storage and a pumping station located at or near a power-generating station. There are innumerable combinations of circumstances between these extremes, and more are developing continuously.

During a major, widespread power outage the lack of water for industrial and commercial users is generally not of prime importance because their operations are often just as vulnerable to the interruption of electric service. The crippling of fire-fighting equipment is a calculated risk, but the risk is not too great in smaller communities where the longest outages will probably occur. The danger in large cities would be much greater.

Human consumption is generally considered the most important use of water, but it is not the only use around the home, nor is it the most extensive. The largest use of water in the home, and often the hardest to do without in an emergency, is for sanitation purposes, particularly for the transportation of wastes from the home. In villages and towns or in the suburban areas of major cities, the lack of water for a day or two would be unfortunate but not necessarily a major catastrophe. In large cities, however, with multi-storied and closely built apartments, hotel offices, industrial establishments, and tenements, and in other areas of high population density, the lack of water for sanitation would create serious health hazards within a very few hours.

For the reasons outlined above, and for many others, the consequences of a failure of water service are much more severe in congested city areas than they are in the small towns, and protection should therefore be greater in those areas. It does not follow, however, that the reliability of service in the less vulnerable areas should be

neglected. The degree of reliability, the expenditures for alternative facilities, and safeguards against outages should be as consistent as practicable with the risk, probable duration, and consequences of an interruption of normal water service.

Electric-Power Outages

An attempt was made to obtain data on frequency and duration of power outages, but complete data are not now available. Available records indicate that outages are infrequent and erratic but, although they give very little help in analyzing the need for reserve facilities, they do carry a definite warning of possible hazards.

The planning of each individual installation must consider those factors affecting the reliability of power supplied to that site. There are few absolute, or general, criteria that can be established, because each situation is different. If there is one universal rule, however, it is that more than one source of power should be available. But even this statement must be qualified under some circumstances, particularly where elevated storage or water from other sources in the system relieves the service area from complete dependence upon that station.

The overall record of outages of the electrical utility presents a fair guide as to what may be expected, but outages that are not too serious to most electrical customers may be intolerable at the water utility's pumping station. Power service to several pumping stations in the same system generally presents entirely different problems at each station.

The reliability of power to pumping stations in most cities having one or more local generating stations can be brought to an extremely high level if the detailed planning, operation of the power facilities, contractual arrangements, priority of power service in emergencies, and continued control of the power supply facilities meet the terms established by or agreeable to the water utility management.

In suburban areas the reliability of available power for pumping stations from local electric lines is often questionable, but duplicate feeders or a looped feeder from separate substations can generally be provided if necessary. The expense to the electric utility of installing duplicate electric lines may be justified by high power rates. Often the rates are too low to cover the extra expenditures, and part, or all, of the cost of duplicate power facilities should be paid by the water utility.

In areas that are entirely dependent upon long electric transmission lines and have no local generating facilities, the reliability of electric service is generally varied. In these instances, the frequency and duration of possible outages must be anticipated. The length and accessibility of the lines between the generating stations and the pumping stations, and the possibility of floods and blizzards, or other factors which would affect the time required to restore service, must be evaluated in determining the hazard of power outages.

A check of the records and memories of difficulties that have caused serious curtailments of service indicate that most of the troubles, particularly outages of long duration, resulted from causes other than power failure. Nevertheless, continued efforts should be made to improve or maintain the reliability of power.

Multiple Sources of Electric Power

Any electrically operated pumping station that is the sole means of water distribution should be supplied by at least two electric services.

In major stations where the consequences of outages are serious and the allowable duration, as determined by storage capacity or other sources of water, approaches the maximum estimated time needed to restore power, the number and reliability of sources of electric power should be increased.

It is probable that electric power will be used at most new stations and in the rehabilitation of many steam stations. In stations located in or near major cities, the desired reliability is generally provided by multiple electric feeders. The maintenance of existing steam machinery for emergencies is expensive, and its reliability is often questionable after a short time. The installation of gasoline engine standby pumps or generators may be justified where duplication of electric facilities cannot be achieved, but this is rarely sufficient, particularly in large installations needing several thousand horsepower.

If at all practical, major electrically operated pumping stations should be supplied in part by underground feeders originating at two or more independent power stations or substations. The substations should also be supplied by multiple power stations with some direct, underground feeders. Underground feeders are not as susceptible to damage as overhead lines but, on the other hand, they generally take much longer to restore to service. Using both high overhead feeders and underground services, with each supplied from, or connected with, alternative sources of generation, provides the utmost reliability. This type of service, combined with priority rights to available power in emergencies, proper control and operation of the electric utility, and dependable on-site electrical facilities, probably provides the best reliability in pumping operations.

Where two or more electric pumping stations supply the same distribution system, or systems, and good service can be maintained with only one station in service, the need for multiple feeders from multiple sources to each station is diminished, but similar reliability should be provided to all stations. The greatest protection against imaginable emergencies would probably result from having part electric and part steam- or engine-driven stations. It is highly questionable whether the increased dependability is worth the additional cost of such combinations.

In systems now having their own on-site power generation, the continued use of part of these facilities, along with new electric stations, may be justified, but as the need for replacement continues it is probable that the proportion of electrically operated stations to other types will increase.

In systems having large enough volumes of effective elevated storage that momentary outages would be practically unnoticed and outages of several hours would not create hazardous condictions, the number of multiple electric feeders may be reduced, but not to less than two. Any single feeder or source of power may be out of service for a considerable period of time for routine maintenance or repairs. A direct-pressure system should have at least two extra feeders, while a system with storage capable of providing protection against short outages could safely rely

on the remaining single service for the emergency period. Even the system with storage should have a third source of available power, although it might be a normally less reliable connection than the principal feeders and some readjustment of other electric loads might be necessary to make it available.

Pumping operations for outlying regions are increasing rapidly, and considerably more attention should be given to the reliability of these stations. In most instances they are, or will be, unattended and the use of electric power will be dictated by costs, locations of residential neighborhoods, methods of control, and other factors. Remote control, and a means of checking of prevailing conditions in the station and at strategic locations in the system, should be provided for normal operation and prompt action in emergencies.

Outlying pumping stations serving major areas should also have reliable, multiple electric services. Often two or more stations can be interconnected through the same pipe grid so that limited service can be maintained from one station and from storage. In most instances, service from these outlying stations should be protected by substantial elevated storage. Elevated storage in the fringe areas is generally essential in order to equalize extremely high hourly demands and to facilitate the operation of unattended pumping stations. Strategically placed ground storage, normally used for repumpage during peak periods, provides additional protection in emergency power outages. The protection supplied by multiple stations is effective only when each station has a separate source of power. In many instances the use of multiple stations is economically justified and desirable from the standpoints of transmission, congestion of existing station sites, and the protection afforded by diversification within the system itself.

Standby Power

Gas, gasoline, diesel, or dual-fuel engines, directly connected to pumps or driving electric generators, or a combination of the two, are the practical sources of standby power at most pump stations where there are not sufficient alternative electric-power sources.

Generally, in the principal stations in most larger, and some moderately large, cities, multiple feeders can provide the desired reliability at much lower costs than standby equipment. In smaller systems, on the other hand, high-speed, engine-driven pumps or generators can be provided for partial or complete standby at relatively small cost. In many of the smaller systems where the pumping stations are at isolated locations and dependent on long electric transmission lines engine-driven standby equipment is essential.

Elevated storage is a source of stored power, and should be planned as a reserve against outages as well as for equalization and fire purposes. Elevated storage must be increased as service expands if reserves for outages are to be maintained. Often the construction of elevated storage for reserve can be justified whether or not it is needed for equalization.

Multiple stations and repump storage, with ample capacities and adequate interconnections through the distribution system to furnish reasonable service during an outage of one station, constitute a form of standby power and provide reliability in emergencies and flexibility in normal operations.

Summary

Some of the principal points discussed in considering alternative sources of power for pumping stations are, briefly:

1. Electric power from central generating stations has become, or is becoming, the dominant type of power used in water works pumping operations.

2. The number and importance of outlying booster and repumping stations in many systems have increased materially in recent years and will continue to do so, probably at an accelerated rate.

3. A very high degree of reliability can be achieved by most major electric pumping stations serving larger cities, and in smaller systems where pumping stations are near the electric-power sources, by the careful planning and provision of multiple electric feeders.

4. Outlying stations in major systems are generally electrically operated, and their reliability should be consistent with the dependence upon them. Multiple electric services, elevated storage, and distribution system connections with other stations should be planned to provide protection equal to, or approaching, that available in those parts of the core city served by the principal pumping stations.

5. Adequate systems of remote control should be provided so that constant information on prevailing conditions at critical points is available and so that prompt action can be taken in emergencies.

6. Most smaller systems, and some larger ones, will find engine-driven standby equipment essential or more economical as an alternative source of power during emergencies.

7. Elevated storage and strategically located repump storage have great intangible value in emergencies as well as in normal operations, and this value should not be overlooked in economic considerations.

8. The provision of reserve facilities to insure reliable service should be considered as an obligation of the water utility even though direct monetary evaluation of these reserves is difficult or impossible.

9. Provisions for highly improbable or fantastic emergencies or for the effects of total war are impractical and probably impossible.

Public Acceptance of Inconveniences During Utility Construction in Streets

Burton S. Grant

A paper presented on Apr. 22, 1958, at the Annual Conference, Dallas, Tex., by Burton S. Grant, Asst. Gen. Mgr. & Chief Engr., Dept. of Water & Power, Los Angeles, Calif.

WHEN the water utility is required to install facilities in public streets, the citizens may easily lose sight of the obvious benefits if misunderstanding and irritation are caused by the inconvenience associated with the project. With good planning and execution of simple but logical measures which will require very small added costs, it is possible to create an understanding of the project by the residents and businessmen and thus gain both acceptance of the temporary inconvenience and a good public reaction toward the utility.

People naturally expect the services of a utility to be available in their homes and places of business, and will readily undergo the necessary inconveniences of having these services installed and maintained. Nevertheless, when installations and repairs call for the use of the public streets, the utility should conduct itself like any good neighbor and inform the public of the reasons for, and the nature of, the work to be done. Whether a street actually belongs to the owners of the adjoining property or to the political subdivision having jurisdiction over it, it is natural for property owners to take a proprietary interest in it and complain when anyone starts excavating it without first informing them.

By being informed, consulted, and asked for permission before construction is undertaken, the residents gain the feeling that they are aiding the utility and contributing something useful to the whole community. Taking and using a neighbor's property without his consent is bound to make him angry. It is easy to ask him, and he is much more likely to lend it with good will.

Planned Program

The Department of Water and Power of the city of Los Angeles uses various methods to inform the residents that work is to be undertaken to install water system facilities in the street in front of their property. The procedures discussed herein pertain principally to excavations for pipelines of larger diameter than the usual street main.

This department is of sufficient size to justify a permanent public relations director. The program that is outlined here was developed through the cooperation of the public relations division, the design engineers, and the construction engineers. The aims of the program are: [1] to reduce public inconvenience to a practical minimum; [2] to create public recognition of the necessity and importance of the project; [3] to tell local residents frankly of the difficulties and inconveniences that will occur and the steps that will be taken to minimize them; and [4]

to keep alert to meet each individual problem or complaint as it arises, with prompt and courteous investigation and action.

This program can be effectively executed without a large expenditure of funds. Best results should be obtained by a plain, down-to-earth, informative campaign with strong emphasis on the person-to-person approach. High-pressure tactics are not recommended.

A clear and concise statement should be prepared describing the project to be undertaken, its location, and its purpose. If more than one location could have been adopted, the statement should include an explanation of why the particular location was chosen. Particular emphasis should be given to the benefits that will accrue to the public as a result of the project. The statement should describe in some detail the plans that have been made to reduce public inconvenience to a practical minimum while work is progressing on the project.

The statement, with appropriate illustrations, should be prepared as a leaflet or pamphlet suitable to be sent by mail, handed out in door-to-door contacts, or circulated at group meetings.

Cooperation of Utility Personnel

If the public inconvenience resulting from the project is likely to bring complaints to the utility, then all employees who might receive calls must be fully informed regarding the project. If any of the utility employees happen to reside in the area to be inconvenienced, they should be asked to cooperate in the public relations program by getting in touch with their neighbors.

As the Los Angeles Department of Water and Power has about 11,000 employees, there are usually a number living in the vicinity of a project. These receive a letter from the general manager and chief engineer explaining the importance of the project. They are informed in advance of the dates and features of the project, given copies of the information pamphlet, and requested to familiarize themselves with the project so that they can provide accurate information to their neighbors.

Other employees of the utility may be members of clubs and organizations that include residents in the project area. Every effort should be made to locate these employees and solicit their cooperation in explaining the project.

Outside Contacts

Elective and appointive officials of the city, other city agencies, and other utilities that have responsibilities in the area affected by the project should be given advance notification. Personal delivery of the prepared statement, augmented by oral assurances that special attention will be given to any problems arising during construction, will usually engender the fullest backing for the water utility. City councilmen and other officials, if kept informed, are able to answer the questions of those citizens who are prone to complain, and thus obtain greater tolerance for a recognized, essential project that creates temporary inconvenience.

Other utilities or governmental agencies may often have pending improvements and installations in the same street. By timely notification and coordination of the various projects in order to avoid repeated visits and early cutting of new pavements, much can be accomplished in holding adverse public reaction at a reasonable level. All agencies that use the public streets fare much better in the long run if they cooperate with each other rather than try to be purely independent.

At Los Angeles, to make certain that every household, store, office, factory, school, church, or place of business along the route has direct information in advance, a letter, attached to a copy of the general information leaflets, is delivered to each. The letter, signed by a top department official, tells of the necessity for the construction work and the care that will be taken to minimize inconvenience. It asks for cooperation and understanding. In order that individual problems can be met as they arise, the letter provides the name of the contractor and his superintendent and the name and telephone number of the department engineer overseeing the project, who is ready to assist in solving special problems or dealing with emergencies. Personal calls are made on the managers of apartment houses and hotels, school principals, pastors of churches, managers of industrial establishments, and at other places along the route where the gathering of a number of people might create special problems during the pipeline construction.

Public Protection

Whether the project is performed by the utility's own forces or by contract does not change the citizens' attitude toward the inconvenience. If work is done by utility forces, the construction organization must understand the importance of reducing public inconvenience and must cooperate with the public relations program that is adopted.

When the work is contracted out, specifications must be explicit on features required to reduce inconvenience, and the contractor must cooperate and participate in the public relations program. Personal discussions with contractors to explain in detail the intent of the specifications and the spirit of the campaign will usually result in full and willing cooperation.

Certain basic provisions are commonly used quite successfully in specifications for work in streets, such as:

Dust abatement. During the performance of the work, the contractor shall furnish all labor, equipment, and means required, and shall carry out proper and efficient measures wherever and as often as necessary to prevent his operations from producing dust in amounts damaging to property or causing a nuisance to persons living nearby or occupying buildings in the vicinity. After the excavations in streets have been backfilled, the dust abatement measures required hereunder shall be continued by the contractor until resurfacing is completed, or until . . . the contractor is relieved of further responsibility in connection herewith.

Trees and other vegetation. The contractor shall exercise due care in passing or operating equipment beneath or adjacent to trees to prevent damage to such trees. Trees, plants, or shrubbery shall be trimmed or repaired and broken branches removed at the contractor's expense in a manner satisfactory to the owners or local authorities.

Interference with highways. In all streets in which his work may interfere with the ingress and egress of the occupants of the abutting properties, or of their vehicles, the contractor shall maintain temporary practicable means of ingress and egress, or shall make satisfactory arrangements with the occupants for the obstructing of ways to their properties for the duration of the interference. If at any time the work is stopped because of inclement weather, the contractor shall keep a representative on the site of the work to insure that driveways or passageways are kept in a condition suitable for safe passage, and shall immediately take steps to maintain such a condition at all times.

There are a number of specifications that are helpful in protecting the public

in the area. Two are quoted here as examples:

The contractor shall take all reasonable precautions to protect the persons and property of others on or adjacent to the site from damage, loss, or injury resulting from his operations under this contract, except such property as the owners thereof may themselves be under a legal duty to protect. This duty to protect shall include the duty to provide, place, and adequately maintain at or about the site suitable and sufficient guards, lights, barricades, and enclosures.

The contractor shall protect and care for all work until final completion and acceptance. Immediately upon completing each portion of the work, the contractor shall begin, and shall diligently prosecute, the work of cleaning up rubbish, debris, and surplus material and shall leave the site in a neat condition acceptable to the engineer. The contractor shall repair all damage to property, public or private, caused by construction operations.

Timing of Work

Usually the utility has some leeway in the selection of a construction period and can obtain greater public acceptance by avoiding important seasons or events in the work areas.

In Southern California, for example, rain rarely occurs during the summer months. The public is particularly critical of utilities that start street excavations just as the rainy season begins. A reasonable choice of time reduces the public inconvenience.

Businessmen are especially sensitive about any activities in streets that tend to keep customers away from the area and their stores. Christmas and Easter seasons, for instance, are regarded as vital periods and should be avoided wherever possible.

Schools can become critical areas because of the hazard to children and the inconvenience to parents and faculty owing to interference with parking. If construction in the vicinity of schools can be limited to vacation periods, the public relations problem is greatly simplified.

Inspection Service

Small but important details that can quickly incite public protest can readily be overlooked by field crews interested in the progress of the job. Well trained inspectors on the project can do a lot to engender public acceptance by insuring that many minor items are taken care of promptly without prodding by the public.

For example, barricades must be used in sufficient number to be effective in protecting the public from inherent hazards, but yet in such a way that they do not also create unnecessary inconvenience. Plating and bridges must be placed promptly to permit free movement of traffic and public access to homes and business establishments.

Cleanup operations should never be allowed to lag. Temporary resurfacing should be applied early and should be well maintained. Sprinkling facilities and a rotary broom used often to abate dust can be great aids to public acceptance during a project. The simple gesture of calling at a home and suggesting that the owner might like to place his car in the street before a trench is cut in front of his house is always appreciated and is taken as evidence that the utility is thinking about the public welfare.

Use of Signs

A recent survey of the utilities operating in the Los Angeles area discloses that they still believe there are certain negative factors which outweigh the positive benefits of using special signs.

Utilities in Southern California generally do not use signs to explain the reason for tearing up a street and apologize for creating inconvenience. When utilities contract their work, there is usually no identification of the utility. One of the arguments against the use of signs is that if clear identification were made by special signs, there might be more claims filed for alleged personal injuries and damages. It is also felt that apologetic or defensive wording is not helpful and that, in fact, the frequent appearance of an apologetic sign could produce an adverse effect on public opinion. Most of the utilities have recently been considering more general use of signs, however, and they frequently inquire about the thinking of others on this subject.

On the other hand, there appears to be increasing acceptance of the view that there is value in having constructive signs that can point out the necessity of projects for meeting a community's growing needs. If it is decided to use such signs, then some judgment is required as to the frequency of use, location, physical appearance, and wording to insure the greatest possible benefit.

For the purpose of provoking discussion of the use of signs, some general principles are suggested:

1. The sign should be used only on large projects that will require some time to complete and that will create traffic and pedestrian inconvenience. If the sign is used on small jobs, it then appears too frequently and the repetition is very likely to result in public irritation.

2. The sign should be clean, attractive, and large enough to be seen. Lettering should be large and the message brief so that passing motorists can read the sign at a glance.

3. The sign must emphasize the importance of the work in terms of human or community needs—for example: More Water to Serve You.

4. The sign must bear the name of the department. A symbol or abbreviation could be used in place of a full name. Occasionally a catchy nickname can be used, such as "Con Edison," the well known nickname for the Consolidated Edison Co. of New York.

Conclusion

The utility that seriously follows the policy of reducing public inconvenience by reasonable measures will find that its future will contain fewer public relations problems. If the good will of the citizens is secured while the utility is contributing to their inconvenience, this will very effectively supplement the day-by-day task of maintaining a good reputation through good public relations practice. The entire community will gain a better understanding of the water department and its problems. There will be a positive recognition that the water utility is interested in the welfare of the citizens and an appreciation by the people that the utility is constantly planning and working to insure that their water needs are met.

Detection and Location of Underground Leaks, Pipelines, and Valves

Norvel E. Ireland

A paper presented on Mar. 13, 1958, at the Kansas Section Meeting, Salina, Kan., by Norvel E. Ireland, Sales Repr., The Collar Co., Kansas City, Kan.

THE obvious reasons for wanting to locate a water leak are that the leak is expensive, wasteful, and dangerous. There are numerous types of leak detectors on the market but, basically, only three ways of detecting leaks are involved: by sight, by sound, or by "supernatural" means. As there does not seem to be any established procedure or scientific proof of the last of these, only the first two methods will be discussed here.

If the leak or evidence of it can be seen, it can be located. For example, water coming out of the ground which lies atop a water main very often indicates a leak directly below. Another sight method assumes that the heat from escaping water will melt snow on the ground above. Hence, scrutiny of a suspect location after a snowfall may reveal a leak.

Most leak-locating equipment employs amplification of the vibration produced by the escaping water as it strikes the surrounding soil.

The simplest type is the mechanical amplifier, which resembles a doctor's stethoscope. This instrument is essential; every water distribution superintendent should have one. In use, the "pickup" is placed on exposed parts of the system such as a hydrant, valve, meter pit, or house faucet or piping. Because no electrical amplification is used, detection of a leak sound is positive indication that the leak is nearby; the closer to it, the louder the sound. This equipment is easily operated and can be carried in a pocket or dash board compartment of a service truck. Although several manufacturers make this instrument, all perform in exactly the same way, and none is superior to the others. Price ranges from $3 to $8.

Battery-Operated Detectors

Battery-operated leak detectors—which amplify the sound electrically—generally increase in price with increases in power and efficiency. Money spent on this equipment is a wise investment for any water utility. If properly used it will pay for itself very quickly and continue to pay for itself several times yearly. Most such detectors have a visual indicator which actually interprets what is heard by the operator. The visual indicator employs a gain control with which the operator attempts to get the loudest sound using the least power. Usually, all power is needed to detect the leak.

In using this equipment, a preliminary survey is first made by placing the instrument on each of the fire hydrants or main line valves in the water system. If a leak is indicated at a hydrant, a notation is made and the hy-

drant is tightened as much as possible with a wrench. This is done because many of the leaks in distribution systems are in the hydrants themselves. If the hydrant has been leaking, the leak indication will change after tightening.

In one town with a 45 per cent water loss it was found that nineteen of 21 hydrants were leaking. Of the nineteen, seventeen were impossible to shut off.

Instruments of the battery-operated type can usually be depended upon to detect a leak from one-half to one block away. When the survey of the hydrants is completed, it is assumed that the leaks are in the area with the largest readings. The next step requires checking of all services in that area while keeping alert for disconnected services. Each service is checked at the meter pit or curb stop. If a leak indication is given for any service, it is shut off at the service stop. After waiting long enough for line pressure to be released, the stop is checked again. If no leak indication is found, it is quite obvious that the leak has been stopped and that it is on the customer's side of the service stop. If a leak indication is found on several services and an especially loud one on a particular service, it is a fairly safe assumption that the leak is on the main closest to the service with the loudest reading. As a general rule, vibrations from a service will not travel out to the main and down it to other services. Hence, if a leak indication is found on only one service in a certain area, it is fairly certain that the leak is on this service. Of course, there are exceptions which a leak detector operator soon learns to recognize.

After determining that the leak is on the main, the next step is location of the pipe. It is the author's experience that the leak vibrations travel along the pipe or through the water for considerable distances and tend to be propagated straight up from the leak, over which they are confined to a small area. If the vibrations are detectable, the operator can assume himself to be fairly close to the leak.

The microphone is placed directly above the main and moved approximately 6 ft each time, until the suspected area has been passed. If the leak is not detected the procedure must be repeated, the microphone being moved only 2 ft at a time. If detection is still unsuccessful, the procedure must again be repeated, moving the microphone approximately 12 in. each time. If still unsuccessful, a rod should be driven down to within 1 or 2 in. of the main. The microphone should then be placed on the rod and a reading taken. This procedure is repeated until the leak is found.

Leak-detecting equipment, an invaluable aid to any water superintendent, will not operate by itself. Its use requires patience and common sense. Actually, 40 per cent of the success in locating leaks is ascribable to the machine and 60 per cent to the operator.

Location of Valve

After the leak is found, the next step is location of the valve so that repairs can be made. To locate the valve—and, sometimes, to save many hours—it is essential to determine first the exact position of the buried pipeline to which it is attached.

The same three principles used in leak detecting are used in pipe locating.

Some water utility operators are capable of determining the exact location of pipelines simply by scrutinizing the terrain. Exposed valve boxes also in-

dicate positions of buried pipe and, again, there are several types of mechanical and electrical devices available for locating pipe. Costs of such devices increase with their efficiency.

Pipe Locators

There are two basic types of electrical pipe locators—the conductive and the inductive—and there is a definite need for both. The conductive type sends a current of electricity into the pipe which is thereby made traceable for considerable distances. This locator has several advantages over the inductive type. It is generally more accurate, limits detection only to what has been energized, and eliminates interference from other metallic lines or objects. Instruments of this type are usually rugged and simple to operate. Relatively little time is required for an operator to develop skill in their use. Single masses of metal, such as a valve box or a manhole cover, cannot, however, be detected by them.

The inductive type also has its advantages. Best results are obtained when the instrument is used as both transmitter and receiver. Using it in this way eliminates the troublesome need to energize the line. With this type of instrument it is also possible to locate isolated buried metal objects such as valves without valve boxes, valve boxes, and manhole covers. This advantage is sometimes worth the cost of the instrument. One manufacturer has recently improved his inductive-type locator by using transistors and built-in pulsator circuits which help considerably in locating pipelines near high-power lines and other electrical influences. The inductive locators are generally adaptable for use as the conductive type. Such use, however, is not practical, as the energizer is not powerful enough to allow operation at distances greater than 30 ft from the energy source.

The conductive type is effective tc a depth—depending on ground and soil conditions—of 30–40 ft. The inductive type normally can be depended on to a depth of 4–8 ft.

Dip Needle Device

After a pipeline has been located, the area of search for valves is considerably narrowed. Of the several types of instruments available for location of valves, most are magnetic or electrical. The magnetic valve box locator is little more than a large compass, and is commonly referred to as a "dip needle."

As with previously described equipment, price varies directly with efficiency. The principal defect of the common dip needle device is that if dropped or jolted it requires remagnetizing. One needle instrument is mounted in a leather case which makes it much less subject to shock and consequent magnetism loss. This device also is equipped with a mirror which makes the needle more easily visible and eliminates awkward bending and stooping. The common dip needle locator normally has a depth range of 2–4 in. and the type protected by a leather case seems to have a slightly greater depth range—approximately 6–15 in.

Because magnetic locators depend entirely on the amount of natural magnetic attraction in the metal to be found, they are not completely reliable. It is not uncommon, for example, to find a curb box that has no magnetic attraction with which to influence the dip needle—even with the device directly on top of it. Occasionally, it will be found that the polarity in a valve box has been reversed and

that, as a result, the wrong hand of the needle will be attracted. When this occurs, the object may go undetected. A new tool has been developed which imparts an electrical charge to a curb box. This charger is invaluable for anyone using a dip needle locator and saves many hours of work. This tool, when used, imparts a permanent magnetic charge which can be detected from a distance of 2–4 ft. If the charger is drawn back and forth in the vicinity of a suspected valve and if the valve is not more than 2 ft deep, a partial charge capable of being detected with the dip needle will be imparted. After the valve has been excavated, it should be given a direct charge to make future location easier. It is becoming common practice to place valve boxes well below ground level to protect them from damage by grading or snow plowing. It is therefore necessary that the box be heavily magnetized. All types of utility service boxes should be magnetized during the summer when they can be readily located, in anticipation of the adverse conditions of other seasons. The charger can not only put a permanent magnetic charge on a valve box, but reverses the polarity where necessary.

Electronic Detectors

There are several electronic mine detectors or valve box locators available. The author has had experience with only one type of such instrument. The device, amazing in its efficiency, has taken much of the guesswork out of valve box location. Because it uses sound and has a visual indicator, it can be used in daylight or dark. It gives its audible indication by a marked increase in the volume of a constant sound which occurs only directly over the object. The depth range seems to be 2–4 ft.

Water in Modern Fire Control

Mathew M. Braidech

A paper presented on Apr. 22, 1958, at the Annual Conference, Dallas, Tex., by Mathew M. Braidech, Research Director, National Board of Fire Underwriters, New York, N.Y.

NO two fields of technical endeavor are more closely related or mutually dependent than fire protection and water supply engineering. In fact, one could write a story of mankind's growth in terms of its concerns with fire and water. Man's evolution and, doubtless, his destiny are bound up with these two elements in countless ways. As destructive (uncontrolled) and useful (controlled) elements of nature, they have influenced human progress more than any other factors of man's environment.

It may be of interest to recall that the universal importance of these two elements was recognized by alchemists of the Middle Ages, who hypothesized that all matter was composed of four principal materials: air, earth, fire, and water. These key elements were believed to originate in some primal material, which, in an active or passive state, provided the basic qualities of "hot and cold" and "wet and dry." From this it was assumed that the form of any given type of matter depended upon a specific balance of these opposing principles. This colorful hypothesis (out of which, but along different lines, developed modern chemistry) is not entirely inconsistent with modern theories concerning nucleons and electrons.

By intelligent control and technological adaptation, the elements fire and water have become producers of power to alleviate human toil, promote and increase productivity, and, at the same time, provide social stability through advancing standards of health, comfort, and physical security.

Problems of Expansion

Modern civilization and its expanding technology are making heavy demands for increasingly large and better supplies of water. The country's industrial and economic makeup is constantly changing. The implications for the water industry of new inventions and processes, growth in population, and industrial expansion have not commonly been given the proper attention until recently. The boom and shift in population to outlying suburban and remote rural areas and the decentralization of industry are bringing about many-sided problems in fire prevention and control and explosion safety.

Since 1946, thousands of factories, warehouses, industrial plants, and small, adjoining communities have blossomed out on the remote fringes of the population centers where there is greater space for future growth. Because of the cost of handling materials and the trend toward straight-line flow in industrial production, traditional, vertical, multistoried construction is giving way to the quickly and easily erected, relatively mainte-

nance free, one-story, horizontal construction. To provide for rearrangement of operations and adaptation to automation, many of these larger structures are running into areas of millions of square feet under a single roof.

New Fire Hazards

New developments and transformations in manufacturing establishments are being accompanied by high concentrations of value in property used for the storage and handling of many new flammable substances and violently reactive chemicals, in addition to increasingly larger volumes of older dangerous materials. The efforts of insurance and industrial-safety personnel and municipal fire authorities to provide the necessary emergency fire protection for the growing array of potential hazards are being seriously taxed. Of significance are two disturbing facts: [1] that, in the wake of giant industrial steps, 200 factories and businesses are being destroyed each day by uncontrolled fires; and [2] that there has also been a sharp increase, in recent years, in the number of large-loss fires —those over $250,000 have approached nearly 400 a year, representing 0.1 per cent of all fires, and are responsible for approximately a third of the monetary losses, which total over a billion dollars annually (Fig. 1).

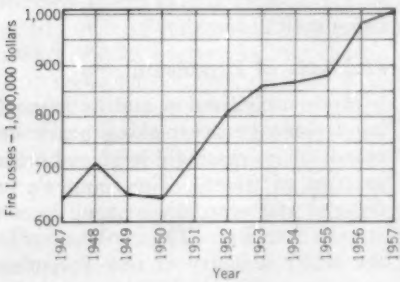


Fig. 1. Nation's Rising Fire Losses

Over the 10-year period 1947–57 annual fire losses nearly doubled, reaching a billion dollars in 1957.

Probably no other single industrial fire created more widespread interest than the epoch-making $50,000,000 fire that occurred only 5 years ago at the General Motors hydramatic transmission plant in Livonia, on the outskirts of Detroit (Fig. 2). This was the largest single property loss in insurance history. Special significance is attached to its seriousness by the fact that the damage exceeded that of more than 80 of the largest industrial fires and explosions during that year and equaled that of the conflagration which devastated more than 80 blocks in the city of Baltimore just 50 years ago. This serves as an example of the heavy damage possible in a single fire, especially in many large, modern establishments, with mounting stock inventories, concentrated equipment, and high building values. The vulnerability of so-called noncombustible construction was exemplified by this catastrophe. The asphalt roof over the 1,500,000 sq ft of undivided working space supplied about 2,000 tons of fuel. Fire is always accompanied by destructive effects other than those of direct burning. Thermal distortion and deformation by radiated and conducted heat can buckle bare steel and cause structural collapse, destroy machinery and goods in process of fabrication, and lead to serious and costly stoppage of high-speed production operations. More than 3,000 machines were seriously damaged and 30,000 workers idled for weeks by the Livonia fire.

To demonstrate that fires are no respecters of national boundaries, in 1957 a similar conflagration occurred

at the Jaguar automobile factory in Coventry, England. The building was a large, single-story, unprotected steel frame structure, with a combustible roofing of bitumen and an internal lining of fiberboard insulation. No separation of areas was provided, and there was no sprinkler system. Flaming drops from the roof spread the fire with extreme speed, causing almost complete burnout.

Fig. 2. Fire at General Motors Hydramatic Plant, Livonia, Mich.

This is the largest single industrial fire ever recorded. Total losses were estimated at $50,000,000.

Growing Demand for Water

Modern civilization is imposing heavy demands on water supplies. Many towns, cities, industries, and farms are expanding beyond safe limits of readily available water. Technological developments could not have been attained at a level of water consumption geared to the requirements of primitive, simple society, which had a one-time minimum requirement of 5 gpcd (present demand varies from 50 to 300 gpcd, depending on the community). In many regions, shifts in population have caused growth far beyond normal expectations, with big drains on the local water supplies. In addition, fire protection facilities, originally set up to handle small-town garage, store, and dwelling fires, have been rendered inadequate, if not obsolete. To make up for these deficiencies, the problems of industrial expansion, with its associated hazards, and critical water shortages must be given hand-in-hand consideration. In the water supply industry, more thought is being given to advance planning of storage reservoirs, aqueducts, methods of recharging depleted or limited underground resources, reclamation of

waste waters, and conversion of sea water by various methods.

One must submit that the water industry is facing up to its important dual task of providing water of the required quality and in the needed quantity. The achievement of safety in the quality of water has contributed outstandingly to the health of the nation. The willing response of the water industry to growing demands and precise industrial requirements is exemplified by its ability to meet the ultrapure specifications of the nuclear-power program, which calls for a purity of 99.999995 per cent, or a feedwater with not more than 0.05 ppm dissolved solids, to preclude pickup and carryover of radioactivity imparted by nuclear radiation to the dissolved mineral matter in reactor coolants. Water of similar quality is being called for in new modern boilers, which will produce nearly 3,000,000 lb/hr of steam at supercritical pressures of 3,500 psig and temperatures of around 1,200°F.

Fig. 3. All-Out Protection Against Fire in a Chemical Process Area

Combined efforts of hose streams and spray systems held a potential loss of $8,000,000 to only $75,000

Next to irrigation, industry and steam power plants use the largest amounts of water. Its importance in power production and controlled combustion in industry is indicated by the fact that 600–1,000 tons of water are required for each ton of fossil fuel burned in steam production, and as much as 8,000 tons are needed to produce a ton of aluminum. Almost every industry

depends upon water, with its thousands of specific applications.

Fire protection engineering is also being challenged to meet its share of responsibility. There has been a stepped-up interest in the fundamental science and practical art of prevention and control of fire and explosion and in more effective and prompt extinguishment of all types of fires. A closer look into the various mechanisms of ignition, spread, suppression, and extinguishment of flame and incandescence is already providing information for better utilization of water in the control of fire and in explosion prevention.

Although the general economic essentiality and versatility of water have been stressed in various surveys, reports, treatises, and learned discussions, recognition of the vital role of water in fire protection has not been as fully accorded as it should be. Fire emergencies call for a large flow of water at the right time and at the right place. In its periodic inspection and grading of fire defenses in cities and towns of the United States, the NBFU (National Board of Fire Underwriters) has for many years recognized the prime importance of a continuous and dependable supply of water to all parts of the areas supplied. For proper fire protection in principle commercial centers, high-value business districts, and congested industrial areas, water systems are expected to deliver at all times the maximum fire flow requirement to meet certain prescribed emergency conditions. The grading schedule is based on a weighted, point deficiency and some 30 items concern water supplies, which can amount to 34 per cent (or 1,700 points) of a total of 5,000 points. With gradings for fire department and fire alarm facilities (1,500 and 550 points, respectively), these three key items alone can account for 75 per cent of the municipality's grade and rank in any one of ten classes showing relative protection in cities, towns and villages.

Requirements of the NBFU for fire flow in the principal business districts of municipalities range from 1,000 gpm, for a population of 1,000, to 12,000 gpm, for a population of 200,000. The minimum duration ranges from 4 hr for a fire flow of 1,000 gpm to 10 hr for fire flows of 2,500 gpm or more. In cities over 200,000 population, an additional 2,000–8,000 gpm may be required for a simultaneous second fire, depending upon structural conditions and the degree of congestion of buildings in the principal business district. Requirements in other areas are based on similar standards and determined by individual studies.

Fire Control Properties of Water

Technology and innovation are so thoroughly associated with new methods that the ability of science to help us explain the old techniques is often forgotten. This applies in particular to water and its utility as an effective agent in fire protection. Water, in spite of the aforementioned shortages of supply, is still the universal fire-extinguishing medium. Its liquid (or vapor) state, ease of application, and ready availability—when adequate supplies are maintained—are its main advantages. No inexpensive substitute appears attainable. One of its outstanding qualities is that it is not easily destroyed or actually consumed, but is capable of continuous and repeated use. The reason for its ability to extinguish flame or suppress combustion is its thermochemical stability, its capacity to cool, smother, or dilute burn-

ing materials. Fire temperatures, in ordinary burning of most materials, usually reach around 900–1,800°F (dull-red to cherry red heat), and rarely exceed 2,500°F (white heat). When the temperature is reduced to 300°F, which is lower than the ignition temperature of most materials (a few exceptions are yellow phosphorus, 86°F; carbon disulfide, 212°F; and cellulose nitrate, 229°F), combustion ceases and extinguishment is accomplished. Smothering and steam dilution, on the other hand, reduce the concentration of flammable vapors to less than their combustible limit, help to reduce the concentration of atmospheric oxygen over the burning material from the normal 21 per cent to about 15 per cent, and thereby assist in snuffing out the fire. Proper application of water results in a combination of these two effects and promptly controls and extinguishes most fires (Fig. 3).

Water has a number of properties that are comparatively unusual. Its dielectric constant is uncommonly high, as are its surface tension, specific heat, and heats of evaporation and fusion. The latter two values are high because of the low molecular weight of water. No other simple chemical compound comes so close to being so economical a universal solvent and coolant. Its large thermal capacity and high opacity to radiant heat make it the most effective coolant and barrier to heat energy—two valuable factors in fire fighting.

Among water's valued properties is a relatively high electrical resistance. Ordinarily there is no danger when low-voltage, live wires are approached with hose streams, but there is a shock hazard in emergency breakdowns that involve an abnormal amount of electrical charge. In broken streams or sprays, however, little current is carried, and the danger can be reduced appreciably. Safe distances for water streams are governed by the mineral content of the water. In any event, non-conducting (low in carbon-black) rubber wear, boots, gloves, and clothing will insure additional protection. There is less danger of shock in the application of water through fixed installations than through the use of hose streams.

To understand better the role of water in fire fighting, some of the technical aspects of its application need to be considered in detail. Fundamentally, suppression of combustion and extinction of flame are processes of heat transfer—the transfer of the heat from the flames, gaseous byproducts, particulate, solid matter (fumes and smoke), and the body of the burning substance to the heat-absorbing water. As simply stated previously, the action is either one of cooling by direct contact, shielding from radiant heat, and smothering, or of reduction and stoppage of the vaporization of solid and liquid materials. With the exception of mercury and some concentrated solutions of alkali halides, water has the highest heat-absorptive capacity among liquids.

Understanding the heat removal problem in fire protection does not require the rigorous theoretical and complex dimensional analysis given by chemical engineers to heat transfer processes. Suffice it to say that water exerts its maximum cooling effect when it is applied cold and evaporates into steam. It is an interesting fact that the amount of heat required to vaporize a gallon of water (approximately 9,500 Btu) is nearly seven times as great as that required to raise

it from room temperature (62°F) to the boiling point, while at the same time steam formation produces a volume expansion of 1,700:1. The important point is that any water applied in fire control and allowed to run off will merely be heated and not most effectively utilized. It will be, to some extent, wasted. Billows of condensing steam are a sign of effective water application.

Water Application in Fire Fighting

When a fire gets a good start (because of late detection) and attains considerable magnitude, the quantity of water necessary for manual extinguishment becomes very large. The decision as to the necessary stream volumes in such emergency operations will be governed by the nature of the burning materials, the fire load (amount of combustible content), the external exposure of adjoining properties, the arrangement of the building interior, and the degree of accessibility. Heat, smoke, toxic vapors, or unburnt combustible gases accumulated in confined spaces bring about poor visibility and the hazards of flash, backdraft, and poisoning. A quick survey can be of tremendous importance. Water requirements and emergency procedures can be better established, particularly in industrial protection programs, by advance planning. Plans of possible action permit the exercise of tactical decisions in water use.

In general, any fire that can be fought from an inside position does not call for a volume greater than that delivered by a 1- or 1½-in. nozzle. Residence fires are generally fought with ¾–1-in. tips. Nozzles of 1¼ and 1½ in. are advisable for outside fire fighting. As a general rule, 40–60 psi of nozzle pressure are required for an effective stream in ordinary outside use and inside of large-area buildings. This gives a reach of about 70 ft vertically or horizontally; with pressures up to 100 psi, the reach is extended to around 90–100 ft. No pressure in excess of this is recommended. The standard 1⅛-in., smooth nozzle provides a good stream of 250 gpm, and delivers more than a ton of water every minute; 1¼-, 1½-, and 2-in. nozzles will deliver 300–350, 500–600, and 900–1,000 gpm, respectively. In combating large fires, one must obtain a stream that can throw a large mass of water into the heart of the fire to drench and soak the most fiercely burning zone. The number of hoses needed will depend upon their length and the capacities of the hydrant and pumper. How best to apply water in fires, whether in a steady, solid stream, by a sweeping action, by short bursts, or in the form of spray or fog, is a subject for long discussion. One only needs to be reminded that 100 gal of water are capable of absorbing almost 1,000,000 Btu and generating over 20,000 cu ft of steam.

Developments in manual fire-fighting operations have brought about various types of spray and fog nozzles, playpipes, applicator extensions, auxiliary heavy-stream devices, such as deluge sets, water towers, and aerial ladder attachments, and special supplemental apparatus. Various types of monitor and turret nozzles have appeared and there are pumper deck guns capable of delivering 500–1,000 gpm or more.

There are three excellent examples of fires that used large amounts of water. The first occurred in Fall River, Mass., some 30 years ago. About 20,000,000 gal of water was used to fight a conflagration that de-

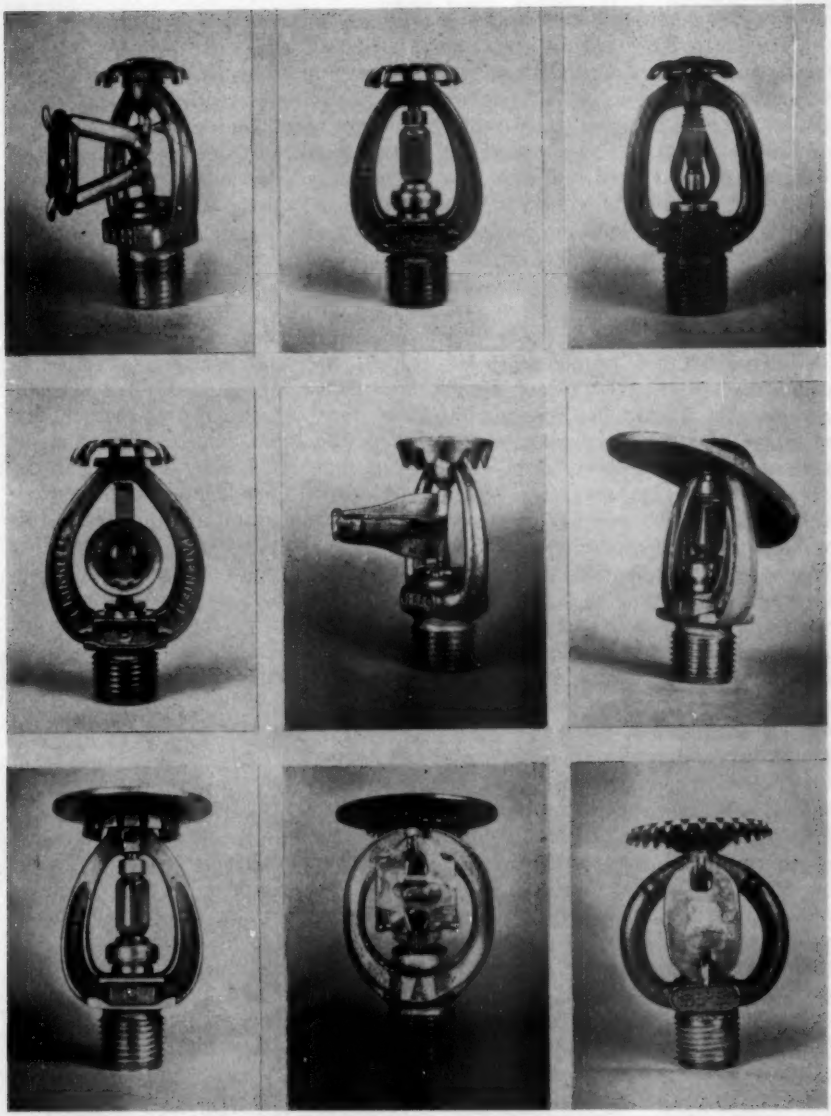


Fig. 4. Examples of Available Types of Spray Sprinkler Heads

Types shown are: top row, solder (link and lever) type, bulb type, and chemical type; middle row, heat collector type, duck-billed type, and side wall type; bottom row, new upright (deflector) types.

stroyed six city blocks in 12 hr and resulted in damage of over $2,500,000. Twenty-one cities and towns sent 32 pumpers over distances of 15–50 mi to assist in the fire fighting. The water usage was almost three times the maximum daily domestic usage.

The second, more recent, fire occurred in the center of the mercantile district of Philadelphia and caused a serious drain on the municipal water supply for a prolonged period. It involved various light-manufacturing companies, including a number of jewelry and optical manufacturers that stored and handled a considerable amount of highly flammable plastic, pyroxylin material. The high-pressure fire system was promptly activated and operated for 25 hr at a delivery pressure of 275 psi with recorded volumes ranging up to 13,000 gpm. Some estimates indicate that peak rates in excess of 16,000 gpm were reached. This unusual fire, involving a group of relatively small manufacturers, required a total fire flow of almost 10,000,000 gal.

The third example is an industrial fire that occurred in 1951 in a synthetic-rubber factory, which, at the time, was essential to the Korean emergency. A pump leak in a process area that was used to convert ethyl alcohol to butadiene almost resulted in a total-loss fire—and would have, had it not been for the planned functioning and ready support of a mutual-aid, plant emergency organization of adjoining industrial establishments. The fire involved a distillation section of fourteen columns, spaced 10 ft apart, and a large tank farm for raw materials, intermediates, and final products located 30 ft away. The fire fighters used 46 2½-in. lines from hydrants, fire pumps, and fire department pumpers, in addition to hand lines, deluge turrets, water tower and aerial ladder attachments. There was a total water flow of 12,000 gpm during 5½ hr of operation. During the first hour, several explosions and flareups, caused by pipeline rupture, occurred periodically. About 32,000 gal of butadiene was consumed by the fire in various pipe and tank areas, and over 25 billion British thermal units of heat was generated. It was estimated that over 30,000,000 gal of water was used with the primary object of protecting the surrounding equipment and process piping against dangerous exposure to heat. The loss in this instance was comparatively small.

The point demonstrated in these examples is that, although the total amount of water used for fire fighting over a year in comparatively small and of no apparent importance, fire emergencies can present unusually heavy peak flow demands. Such demands, even though they may occur only for a short time, are critically important to successful combat with a fire of conflagration potentials and quite disturbing to the normal users of the water supply.

Fixed Fire Protection

Automatic sprinklers are well known for their unequaled record in safeguarding an estimated 100 billion dollars' worth of property. Without their remarkable success, many hazardous processes and important industrial operations could not exist. They are known for their simple operation. Provided with small openings, they spray water over a given area when automatically actuated. Various types of release mechanisms, such as fusible solders, non-solder frangible bulbs, or

easily softened chemical compounds, are activated automatically at different predetermined ranges of temperatures—from 100 to 360°F, and higher. Sprinklers having a nominal ½-in. orifice will discharge about 15 gpm at a working or flowing pressure of 7–8 psi, and up to 35 gpm or more at pressures of 100 psi or more. A floor area of

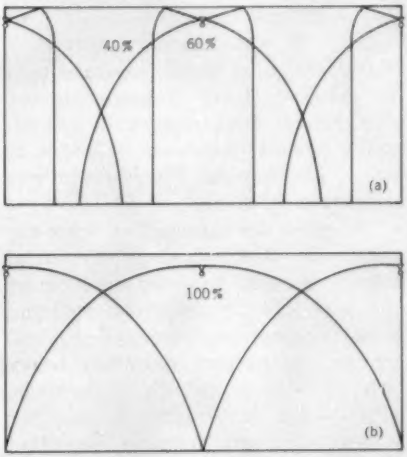


Fig. 5. Spray Patterns of Conventional and New Upright Sprinkler Arrangements

As can be seen from Fig. 5a, about 60 per cent of the spray from conventional sprinkler heads is deflected from the ceiling, after which it falls in large droplets. The newer heads (Fig. 5b) spread 100 per cent of the spray and are therefore much more efficient.

100 sq ft can be covered by one sprinkler. In an average building, one sprinkler for an area of 100–120 sq ft is generally provided.

Some 30 different kinds of sprinkler heads with various adaptations are produced by more than a dozen manufacturers and are available for 93 different kinds of occupancies, classed either as light, ordinary, or extra hazardous. Examples of various sprinkler heads are shown in Fig. 4.

Two principal types of sprinkler systems are commonly employed: the wet-pipe system, in which water is under pressure in the pipe at all times; and the dry-pipe system, in which air is under pressure (25–40 psi) and water (also under pressure) enters the piping system when a sprinkler head opens. The latter system is utilized where freezing conditions may exist, such as in unheated areas and refrigerated warehouses, and, because of its slowness of action, it is not recommended for hazards involving fast-burning combustibles. There are also combinations and modifications of these systems for use under special circumstances. Two of these are the "pre-action" and "deluge" systems. The former are activated by thermostats or other heat-responsive devices, and are designed to eliminate the delay in the discharge of water which occurs in dry-pipe systems; the second are open-head sprinklers or a combination of open and closed sprinklers, controlled by quick-opening mechanical or hydraulic valves, and are intended to wet down an entire area as soon as fire originates, primarily in special, high-hazard occupancies. The water supply requirements may be larger in these systems than in ordinary systems. Other innovations include water curtains for outside exposure protection and water foam spray arrangements for special applications, such as in airplane hangars. New designs are continually being developed to meet the many unusual fire problems brought about by new industrial hazards and new architectural designs (with extended use of air conditioning and windowless construction). Sprinkler

equipment, arrangement planning, installation, and maintenance have become highly standardized, and have called for specialized engineering. The art has reached a stage where systems can be tailor-made to guard against the most dangerous hazard. Installations are governed by and subject to the inspection and approval of insurance company engineers and other appropriate authorities.

Although there has been considerable advancement in sprinkler protection over the original crude, perforated pipe introduced about 75 years ago (1887), there has been no serious change in the automatic feature of its operation in 50 years. Gradual development in system layout is placing greater emphasis on the importance of the correct location of sprinklers as new fire problems develop. The biggest forward step and most recent change took place about 10 years ago with the development of the reverse-spray principle, which brought about the present automatic (upright and pendant) spray sprinkler. A seemingly minor change in the deflector design resulted in important differences in the discharge characteristics and greatly improved efficiency.

The fire spray technique, particularly in hose stream operations, is as old as the art of fire fighting. It was first developed for specialized use as a protective shield and for combating oil fires. The interest in breaking up the water spray into finer droplets was revived during World War II, through the use of so-called "water-fog" by the Navy and the Coast Guard. An interest in the application of this technique to automatic sprinkler heads was aroused because of the intensive combustion of piled automobile tires and the increased fire loading brought about in storage areas by extra-high piling of boxed and crated commodities. The crowding of stock promoted a fast-burning, runaway fire which was too much for ordinary sprinkler systems.

Research showed that conventional upright and pendant sprinkler heads discharged over 55 per cent of their water laterally and upward against the ceiling, and deflected directly downward as coarse drops and fine streams. A change in the design of the sprinkler head, with a flat deflecting disk, caused a horizontal and wide-angle, downward discharge, which had a completely filled, umbrella-like spray pattern and sprayed no water on the ceiling (Fig. 5). This improved distribution resulted in more effective cooling and an increase in area coverage of as much as 25–30 per cent. At the same time this allowed the water to reach the burning material more directly, and no piping changes were necessary. There is now good promise of being able effectively to handle severe fires that have unusually rapid spread potentials. The new spray heads permit sprinklers to be spaced further apart and flow rates to be appreciably decreased because of less loss through friction in cross piping and branch lines. The economical utilization of water flows reduces water damage; often damage owing to excessive amounts of water outweighs the fire damage.

The new spray sprinkler is similar to the older unit in appearance and actuating mechanisms. Spray sprinklers should not be confused with spray nozzles employed to produce fog, vapor, or mists, however, although a great variety of hose and fixed-spray nozzles and sprinkler systems may be used to obtain the required patterns for specialized protection (Fig. 6).

Water Additives

Many methods have been developed over the years for improving the efficiency of water as a fire-extinguishing medium through mechanical changes and methods of application. As previously stated, the problem of fire extinguishment is primarily one of heat transfer and an increase in the efficiency of an extinguishing medium would be an increase in the rate of heat exchange from the surface of the burning material and hot gases to the coolant. Therefore, the area of actual wet contact between the surfaces of the combustible and the mass of water is what really matters. The problem of controlling the spread of fire might be considered as a race between the outbreak of fire and prompt cooling and smothering by a rapid application, at a suitable rate, of the coolant or extinguishant. Time is certainly of the essence with intensely flaming and fast-burning materials, where minutes and even seconds count, and the rate factor also appears to be quite important.

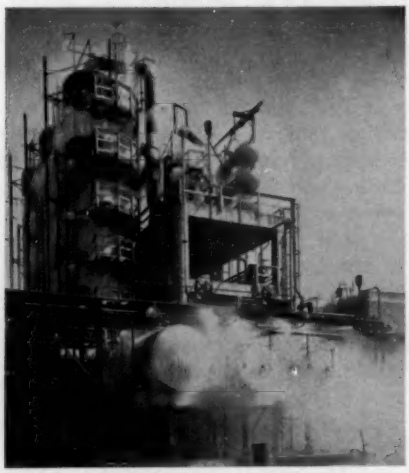


Fig. 6. Typical Structure Protection in Chemical Processing

Sprinkler protection is provided for the tanks, pipe, and all component parts of this styrene distillation–stripping installation.

The problem of a fast-spreading and exceedingly hot fire was exemplified in the Brooklyn-Luckenbach Pier fire and explosion of 1956, where a fire started in a cargo of over 25,000 lb of ground foam rubber scrap in 500 burlap bags, stacked near the center of the 1,760-ft pier. The 7-ft pile (20×20 ft) provided an ideal setting for the extremely rapid spread of flame, which overwhelmed a dry-pipe sprinkler system before the water could be supplied in sufficient volume to cope with the earlier stages of burning. The rate of heat release, approximately 16,400 Btu per pound of rubber, exceeded the designed cooling rate of the sprinklers in a matter of minutes and overtaxed the capabilities of the large number of fire companies responding to the four alarms, given within about 20 min. Within another 6 min, a terrific explosion occurred, shooting flame over the area, damaging windows and structures within a mile radius, and causing ten deaths and injury to about 250 persons. The total property loss was approximately $10,000,000. The fire had spread to a nearby area in which a 37,000-lb shipment of a detonant fuse was stored.

A more recent experience which fortunately involved no life loss and no appreciable loss of building contents, occurred in a partially emptied, central warehouse of a large grocery company. Portions of the building were being reconstructed to provide refrigerated storage. It appears that an oxyacetylene torch was being used near a supply of a new foamed-plastic insu-

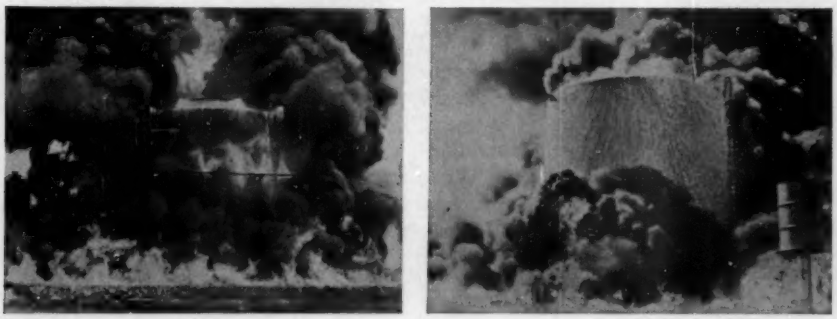
lating material. Approximately three carloads of the material, in the form of 3×18×48-in. blocks, were stacked into a 20-ft pile for use, when presumably a spark set it afire. The high rate of combustion and extreme heat set off 525 sprinkler heads in the one area, some 300 in another nearby space, and an additional 200 in a more distant adjoining area, greatly reducing flow to the sprinklers in the critical fire zone. Fire was finally brought under control and extinguished by the responding fire companies after the main sprinkler was shut off to provide sufficient water for their pumpers.

To enhance the cooling and extinguishing action of water, chemical additives in the form of wetting agents or "surfactants" have been introduced in recent years to reduce the surface tension, enhance wetting, and increase the heat transfer rate. Charred surfaces are ordinarily coated with oil distillates, tarry residues, soot, and smoke, whereas other burning materials may contain films of grease, waxes, and other water-repellent coatings. The addition of surface-active and water-soluble substances to water greatly reduces its surface tension (from 75 to 10–20 dynes per sq cm) and promotes its penetration and spread for unwettable surfaces and emulsification of immiscible burning liquids. Besides effecting extinguishment of deep-seated and smoldering fires by penetrating action, the spread of such treated water over unburnt surfaces also retards the spread of fire. The use of wetting agents on dense, compressed materials and large piles of granular materials and dusts, such as compressed wallboard, baled and stacked hay, sawdust and coal piles, tobacco and cotton bales, and stuffed furniture and mattresses, all of which are subject to burrowing and slow, smoldering fires, has proved quite effective. These chemical agents have also functioned as "gallon stretchers," when used in booster tanks for wetting down brush, organic duff, undergrowth, and field brush fires in areas where water is unavailable. Such chemical treatment is said to foster the spread, penetration, and absorption of water, and thus effect faster extinguishing action.

It is claimed that when such additives are used with ordinary burning materials, such as wood and paper, fires can be put out with one-third to one-quarter the amount of water otherwise required. No shock hazard is presented with fires around live electric circuits when the required amounts of such agents are used, and oil fires, which are hard to handle with water, may readily be brought under control by emulsification and the frothing or foaming action of impinging spray.

With the reduction of surface tension, water has a tendency to froth or foam when agitated. Advantage was taken of this fact with the development of an insulating air–water foam (containing small amounts of wetting agents) to act as an insulating and reflective thermal barrier for large surfaces and areas exposed to radiant heat or direct flame. This principle of "bubble" protection is called fluid insulation and is used in hazardous process areas to insulate equipment against radiant heat from nearby fires. Exposure protection is provided in plant areas for process equipment and storage tanks containing unstable, heat-reactive and toxic materials, and emergency venting devices are used to provide proper pressure relief in the event of accidental overheating. When applied over surfaces of such units, the

foam, because of its cellular structure, serves both as a thermal blanket and a reflective heat barrier, in that radiant heat from the fire is intercepted and reflected away from the surface. The use of a wet-water air-foam results in a thorough wetting of the surface, better adhesion, slow drainoff, and, therefore, a longer time for good heat absorption. In a series of comparative fire exposure tests with burning gasoline, the contents of an unprotected tank (55,000 gal) absorbed heat at a rate of 20,000 Btu/hr/sq ft of wetted interior surface (an established value of heat input employed in the design of emergency venting for safe overpressure relief in pressure vessels under fire exposure). Parallel tests (Fig. 7) showed that the fluid insulation afforded protection equivalent to that obtainable with a standard water spray protection system but required less than half as much water. Both types of protection reduced the heat absorption rate to about one-fourth that of the unprotected tank. Heat absorption rates of about 5,500 Btu/hr/sq ft were measured with a water foam application rate of 0.10 gpm/sq ft; rates of about 5,000 to 7,000 Btu/hr/sq ft were measured with spray protection at application rates of 0.24 and 0.17 gpm/sq ft. The foam was applied as a slow-flowing layer over a small, circular overflow weir, and a cage-like piping arrangement with seventeen nozzles, spread around the test tank, constituted the spray protection system. Mechanical and chemical foams are generally used in concentrations of 3–6 per cent, whereas the wetting agent is used in concentrations of about 1 per cent.



(a) (b)

Fig. 7. Comparison of Conventional Spray Protection and Fluid Insulation

The reduction of the heat absorption rate was about the same with the conventional spray system (Fig. 7a) as with fluid insulation (Fig. 7b), but the latter method used only about half as much water.

Fluid insulation has special prospects for providing fire exposure protection to critical equipment containing heat-reactive, volatile, or toxic materials stored under pressure, and to building structures in extra-hazardous chemical and petrochemical processing areas. Every possible protection is needed to prevent the equipment, storage tanks, and associated piping from rupture (by excessive pressure) or flying fragments and involving other parts of the general area. The use of fluid foam protection also helps to re-

duce the size and cost of necessary emergency venting devices and to reduce the quantity of hazardous, toxic vapors vented from such equipment in highly congested areas.

Special types of wetting agents appear to be required in fire protection. The use of such additives has become pronounced in recent years, and the recent development of standard specifications for their fire service by the NFPA indicates that they will become a permanent and important factor in fire control.

Other chemical additives may in time be incorporated into water to improve the effectiveness of hose-stream and sprinkler application. Injection of sodium bicarbonate (or the charge of a portable, dry-powder extinguisher) has been reported to have a stabilizing, clearing, and sweeping-out action that is useful when there is an excessive release of gaseous chlorine within a building. Mixtures of lime and soda ash, which form a residue deposit or crust to exclude air from burning metal surfaces, have also been added to water for use in large scrap-metal pile fires, with the help of long-range hose streams. One scrap-metal fire involved 3,500 tons of material, piled roughly 40 ft high, called for really difficult fire-fighting operations for more than 50 hr, and required 5 tons of carbon dioxide and approximately 600,000 gal of water. A temperature of 1,700°F was recorded just a foot inside the pile. Such chemicals as ammonium phosphate and aluminum trichloride have also been suggested for their flame-retarding and fire-suppressing effects.

Future Prospects

The principle of successful fire control and extinguishment is to keep originally small fires from becoming big ones. Early detection simplifies the suppression and extinction of fire. It can be said, therefore, that with the proper electronic and mechanical facilities all types of fires could be promptly controlled. Various devices that are responsive to heat, flame, smoke, and carbon monoxide are presently available. Others, which utilize ionizing radiation through suitable radioactive sources, are appearing on the market.

The problem is not so much one of developing new detection or water application techniques as of better utilization of the measures and controls already in existence. It should be anticipated, however, that modern electronic developments may soon provide automatic radio-wave transmission of alarms and the use of servo-mechanisms that will make possible even more effective utilization of water.

In closing, let it be briefly stated that the fire protection and water utility professions have an important mutual calling, dating back far into the past. Looking ahead into the future, one may be certain that both industries will continue to be called upon to protect more areas, people, and property against perhaps even more acute fires than ever before in man's history. In this period of even greater expansion, it is interesting to ask, considering past records, what losses might have been, in lives and natural and created values, without these services.

Legal Aspects of Municipal Fluoridation

Bernard J. Conway

A contribution to the Journal by Bernard J. Conway, Secy., Council on Legislation, Am. Dental Assn., Chicago, Ill.

A CITY, town, or village is subordinate to the state in which it is located. The powers of a municipality may be broad or limited, but they are always determined by the constitution and laws of the state.

Under the US Constitution the individual states retain the full measure of police power. (The US government, at least theoretically, has no police power.) Necessarily, a municipality must share the exercise of the state's police power. The extent of police authority in a municipality is limited to what is delegated by the state legislature. In most instances, however, municipalities in this country have a broad grant of police power to act in protecting the public health and welfare.

Governmental police power is an inherent power of the state. It encompasses actions to protect or promote the safety, health, and welfare of the public. In the US federal system the police power of the states is properly exercised when it is reasonably related to these ends and does not unreasonably interfere with fundamental liberties secured by the US Constitution or the state constitution.

The decisions they have rendered on fluoridation illustrate that federal and state courts have had little difficulty in determining that a municipality had the power to act to protect the public health and welfare in this way. That this is a fundamental fact which must be established, however, is proved by a recent Canadian decision (*1*) in which the court concluded that the city of Toronto, Ont., had not received from the provincial government the authority to initiate fluoridation. In each of the cases litigated in the United States, however, the court has found that the necessary police power was granted to the municipality in either specific or general provisions in its charter or in state laws. In this discussion it is assumed that the delegation of police power to the municipality is sufficient to enable it to act in at least a limited way to protect public health and welfare.

Limitations on Police Power

The police power does, of course, have limitations. Considering only exercise of police power by political subdivisions of a state to further public health and welfare, hundreds of court cases can be found defining these limitations. The fluoridation cases, in the author's opinion, have exhaustively treated the three major limitations of police power: a political subdivision of a state may not use the police power where: [1] action is not reasonably related to one of the recognized goals of the police power; [2] even though otherwise justified, the exercise of power will result in a clearly unreasonable invasion of personal rights secured by the US or state constitution; or [3]

even though otherwise justified, the exercise of power will be clearly in conflict with an overriding US or state statute.

"Reasonable relation to goal" is illustrated by the case of *Chapman* v. *Shreveport* (*2*). The lower court held that the police power to protect public health granted by the state to Shreveport could not be used to justify initiating fluoridation, because that procedure, in the court's opinion, was not reasonably related to protection of public health. To reach this conclusion the court made a distinction between public health responsibilities of the government and personal health responsibilities of citizens. The lower court concluded that since dental caries is not a contagious or a communicable disease, the methods for combating dental caries are:

> . . . Within the realm of individual and personal dental health and hygiene, within which each person should be free to choose his course for himself and those for whom he is responsible in the family relation.

The Supreme Court of Louisiana, however, decided differently. On appeal the upper court held that fluoridation is reasonably related to the protection of public health. In the view of the Louisiana Supreme Court, the public health responsibilities of Shreveport were not limited to methods for combating contagious and communicable diseases. The court stated:

> Children of today are adult citizens of tomorrow upon whose shoulders will fall the responsibilities and duties of maintaining our government and society. Any legislation, therefore, which will better equip them by retarding or reducing the prevalence of disease is of great importance and beneficial to all citizens.

This part of the court's decision establishes as a principle that the reasonable relation limitation of police power is not applicable to fluoridation procedure. The court decided that fluoridation of a community water supply is reasonably related to protection of public health, because it is intended to reduce the prevalence of disease among a substantial segment of the community, even though that disease is noncontagious and noncommunicable.

Whether an otherwise valid exercise of police power unreasonably interferes with certain fundamental personal rights has been by far the most important issue in the fluoridation cases. These personal rights are:

1. The right of each individual to be free to treat his health as he deems best
2. The right of parents to be free to rear and care for their children as they deem best
3. The right to be free from medical experimentation on one's person.
4. The right to be free of interference with religious beliefs.

The Fourteenth Amendment to the US Constitution prohibits the states from enforcing any law "which shall abridge the privileges or immunities of citizens of the United States," or from depriving "any person of life, liberty, or property without due process of law." It is the interpretation of the second phrase which dominates the fluoridation cases.

The right of each individual to treat his health as he deems best has been upheld as one of the personal liberties protected by the Fourteenth Amendment to the US Constitution (*3, 4*). As has been said of all the personal rights protected by the Fourteenth Amendment, however, the right to select methods of health care may be

abrogated by a legitimate and reasonable exercise of state police power to protect public health (*5*). A statement by the late Chief Justice Charles E. Hughes has been a key proposition in measuring the limit of police power in relation to personal rights:

> Liberty under the constitution is . . . necessarily subject to the restraints of due process, and regulation which is reasonable in relation to its subject and is adopted in the interests of the community is due process (*6*).

The pertinent language of the Fourteenth Amendment protects personal liberties only against state action taken without due process of law. It might, therefore, be stated as a principle that any of the personal liberties secured by the Fourteenth Amendment may be abrogated by a legitimate and reasonable exercise of state police power, since such exercise fulfils the requirements of due process of law.

Religious Objections

All of the other personal liberties cited in the fluoridation cases have met the same reasoning, established by a long series of ruling precedents, with one exception. The right to be free of interference with religious beliefs has been treated more extensively and delicately by the courts. A fundamental principle of law is that the action of a legislative body is presumed to be constitutional. One of the few exceptions to this rule is a case which involves one of the First Amendment liberties, such as freedom of worship or religion. In this type of case there is no presumption either way (*7–9*).

The First Amendment to the US Constitution bars Congress from enacting any law with respect to the establishment of religion or prohibiting the free exercise of religion; it expressly governs only the conduct of the US government. By judicial determination, however, the liberties specified in the First Amendment have been included within the liberties to be protected against state action under the Fourteenth Amendment. There are, nevertheless, many state actions which admittedly interfere with religious practices. The prohibition against polygamy, for example, would not be waived for members of a religious group which advocated that practice. Recently, in Illinois, a judge ordered that a child be given a blood transfusion despite the refusal of the parents to consent on religious grounds (*10*).

In the fluoridation cases the specific argument raised to support the claim of interference with religious freedom is that fluoridation constitutes mass medication. Fluoridation would, according to this argument, require those who oppose the taking of medicine on religious ground either to violate their tenets or to obtain a substitute source of drinking water, an unreasonable alternative in the opinion of those who have raised this argument. In some of these cases the judges have ruled that fluoridation of a water supply does not constitute the introduction of a medicine into the water supply, but rather is a means of supplying a beneficial mineral content lacking in the water supply. By this reasoning, the court at least avoids placing full reliance upon a determination that the religious practices of a group must give way to the government's decision to fluoridate the community water supply.

The judges have consistently emphasized that the constitutional guarantee of religious freedom has two distinct components. Freedom of religious beliefs is one, and is guaranteed abso-

lutely; the freedom to practice what is dictated by religious beliefs, however, is not unreservedly guaranteed. A legitimate and reasonable exercise of police power will be upheld, even though it interferes with the freedom of a religious group to practice in accordance with its religious beliefs.

Overriding Statutes

The right of a municipality to limit the exercise of personal liberties in exercising its police power and responsibility may also be related to the "bill of rights" provisions of the US or state constitution. At least one of the fluoridation cases (*11*) has raised the issues of religious freedom and other fundamental liberties primarily in relation to the applicable state constitution. It can be reasonably concluded, of course, that the ruling decisions, whether based upon the state or US constitution, would still support the right of a municipality to fluoridate its water supplies. The only practical difference would be the limitation of appeal jurisdiction: there would clearly be no federal question where only state constitutional provisions are relied upon and, therefore, no opportunity to seek an appeal to the US Supreme Court. Even in spite of the extensive treatment of the US Constitution's Fourteenth Amendment liberties in the fluoridation cases, the US Supreme Court has ruled in four different cases that no substantial federal question was involved, and has refused to review them (*12–15*).

The US Food, Drug, and Cosmetic Act (Title 21, U.S. Code) applies to adulteration of foods. Food is defined in the act to include "articles used for . . . drink for man or other animals." In the case of *Froncek* v. *City of Milwaukee* (*11*) the plaintiff argued that fluoridation of the community water supply was the equivalent of food adulteration and, therefore, in violation of the Federal Food, Drug, and Cosmetic Act. A lower court dismissed this argument summarily on the ground that there was no evidence that 1 ppm fluoride in a water supply constitutes adulteration of food within the meaning of the act.

As far back as 1952, the Federal Security Agency (now the Department of Health, Education, and Welfare) issued an official pronouncement (*16*):

> The Federal Security Agency will regard water supplies containing fluorine, within the limitations recommended by the Public Health Service, as not actionable under the Federal Food, Drug, and Cosmetic Act. Similarly, commercially prepared foods within the jurisdiction of the act, in which a fluoridated water supply has been used in the processing operation, will not be regarded as actionable under the federal law because of the fluorine content of the water so used, unless the process involves a significant concentration of fluorine from the water. In the latter instance the facts with respect to the particular case will be controlling.

Where the state pure food laws or local laws regulating the purity of water have been cited, the courts have consistently held that the fluoridation procedure does not conflict with them (*12, 14*). In all instances, of course, the health authority of the state had officially passed upon the safety of the fluoridation procedure. The fluoridation cases illustrate the significant weight which the courts attach to the official rulings and opinions of federal, state, and local health authorities.

It has been argued, unsuccessfully, that the state laws governing the prac-

tice of dentistry, medicine, and pharmacy are violated by a municipality which initiates fluoridation (*11, 14*). This claim presumes that the introduction of fluoride into the water supply is a form of medication, because it is intended to inhibit the occurrence of a disease. Generally, the courts have disposed of this claim either by referring to the principal justification for a municipality to adopt fluoridation—that it is a public health procedure—or by refusing to hold that the introduction of fluoride into the community water supply is a form of medication.

Proprietary Powers

Some of those who, around 1950, envisioned possible litigation as a result of fluoridation expected that the courts might rule that the initiation of fluoridation comes under the proprietary as distinguished from the governmental powers of municipalities.

The city as a proprietor has the discretion to provide, or not to provide, certain services to its inhabitants. Parks and playgrounds, for example, are provided under the proprietary power. The provision of water is basically a proprietary function; the municipal government may choose to let private sources furnish water to its inhabitants. It might be argued then that the decision to add fluoride to a water supply should be free from challenge from a minority of inhabitants as they could not challenge the right of a city to refuse to supply water in the first place. In the majority of fluoridation cases, however, it has been assumed that the municipality must rely on the police power to justify initiating fluoridation. It can be admitted that furnishing water is a proprietary function, but once it is furnished, whether by the municipality or by a privately owned company, the municipality can assert its right to promote or protect public health through the water supply medium. The users, even a small minority of them, may assert their right to expect that their health will not be adversely affected by any action of the water supplier.

Many of the smaller communities in the United States are served by privately owned water companies. Apparently this does not present a substantial problem in initiating fluoridation. Water suppliers, whether municipally or privately owned, are subject to appropriate state and local regulations and to municipal ordinances. In Oroville, Calif., the city council enacted an ordinance directing a private water supplier to fluoridate Oroville's water supply. The private company refused and the city petitioned the state public utilities commission to order the private supplier to act in accordance with the ordinance. In California, the public utilities commission has broad powers to regulate all private utility companies, including water suppliers. After a hearing at which the effectiveness and safety of fluoridation were argued exhaustively, the commission ordered the private water company to initiate fluoridation in compliance with the ordinance.

It can be assumed that private water companies in other parts of the country would be subject to regulation and direction similar to that exercised by the California Public Utilities Commission (*17*). Recent statistics show that approximately 190 communities served by private water suppliers now have fluoridation.

Safety of Fluoridation

With few exceptions the legal arguments raised against the right of a

municipality to initiate fluoridation under its police powers are intertwined with efforts to show that fluoridation is not effective or that its safety has not been sufficiently proven. In most of the fluoridation cases both sides have presented expert witnesses and have submitted scientific documents on these points. As a matter of fact, a judge is in no position to pronounce that fluoridation is effective and safe. That finding of fact is made by a legislative or administrative body before the case reaches a judge. It is the function of the court to determine whether the material facts about fluoridation, its safety and effectiveness, as determined by the municipal governing body, are supported by competent evidence. The lower court records are replete with testimony on the effects of fluorides on the organs and tissues of man and other animals and on the teeth of persons who have been exposed to fluoridated water. The judges, in disposing of arguments related to the safety and effectiveness of fluoridation, have ruled that there is sufficient competent evidence to support municipal governing authorities' determination that fluoridation is safe and effective and will not imperil the health of any segment of the municipality's population.

Summary

The courts of ten states have held that the fluoridation of public water supplies does not infringe on the constitutional or legal rights of the individual and, under appropriate state enabling authority, is a proper exercise of the charter powers of local communities. These decisions were rendered by the courts of last resort in California (*18*), Louisiana (*2*), Ohio (*19*), Oklahoma (*20*), Oregon (*21*), Washington (*22*), and Wisconsin (*11*), and by trial courts in Maryland (*23*), Pennsylvania (*17*), and North Dakota (*24*). These decisions are strengthened by the fact that the US Supreme Court has refused to review four of these decisions (*2, 18–20*) for the stated reason that no substantial federal constitutional question was involved.

In marked contrast to the number of favorable decisions is the fact that only one court in this country has ever rendered an opinion adverse to fluoridation (*2*). In that one instance, a trial court in Louisiana rendered an adverse opinion, which was promptly reversed by the Louisiana Supreme Court, an action which the US Supreme Court refused to review.

This unanimity of judicial opinion—an unusual fact in itself—gives strong support to the proposition that fluoridation satisfies every legal and constitutional criterion. Opponents of fluoridation have alleged that the procedure violates constitutional rights, such as religious freedom and other fundamental liberties. They have argued that fluoridation represented the unlicensed practice of medicine, dentistry, and pharmacy; that a community had no legal authority to adopt fluoridation procedures; that fluoridation was "mass medication" and a "poison"; that no reasonable relationship existed between it and the public health; and that the prevention of dental decay was not a proper object of community government efforts. Every conceivable legal and constitutional objection to fluoridation has been argued unsuccessfully in the cases that have been litigated on this subject. In the one case in which a trial court held against the fluoridation procedure, that decision was reversed by the state supreme court.

Further discussion of the legal aspects of fluoridation may be found in various publications (*25–27*).

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Hydraulically Backwashed Stationary Screens for Surface Water

Ernest W. Whitlock and Robert D. Mitchell

A paper presented on Apr. 23, 1958, at the Annual Conference, Dallas, Tex., by Ernest W. Whitlock and Robert D. Mitchell, Partners, Malcolm Pirnie Engrs., New York, N.Y.

ALTHOUGH very little documentation is available on the subject, the use of hydraulically backwashed screens on pump suctions is probably as old as the use of screens on inlets to pumps. The use of hydraulically backwashed screens not directly attached to surface water pump suctions is rare, although the authors' firm has used various applications of the idea for over 20 years.

In none of the installations described is the well screen attached directly to the suction of a pump. For many reasons, it is often impracticable to permit backflow through the pump to backwash the screens. Foot valves on horizontal pump installations make the backwash procedure difficult. On vertical pumps it is often desirable to prevent backspin, and unless hydraulically undesirable connections are made in the line piping, the backwashing procedure is difficult to control. In many instances where the water system is supplied by gravity, no pump at all is concerned.

Origins

The author's firm designed an installation with a hydraulically backwashed screen for an industrial supply in South Carolina in 1935. The installation, which was made at the end of a pipeline and was therefore under some pressure, consisted of a pressure vessel into which unscreened water was admitted. A cylindrical screen was stretched over a structural frame inside the vessel. Line pressure was used for backwashing and, by manipulation of valves, screenings were discharged to waste. This screen was not unlike those widely used on small piping to protect control equipment from clogging.

In 1940 two somewhat different installations were made on outlet pipes from water supply reservoirs serving Waterbury, Conn. Each installation consisted of a two-compartment intake from the reservoir, in which one or more well screens were connected to the outlet pipe. In the earlier installations the well screens were mounted vertically, as shown in Fig. 1. The valving arrangement permitted the intake to be closed while a drain from the compartment was opened. Water flowing from the second compartment through its well screen would flow backward into the first compartment, and would thus wash the screened matter from the screen. Screenings would then be disposed of through the drain in the bottom of the compartment. These installations proved highly successful, and the third reser-

voir of this system was similarly equipped some 15 years later.

Operating Advantages

At this point some comment on the reasons for using this type of screen is appropriate. The first installations on reservoir outlets were made because of operators' complaints concerning

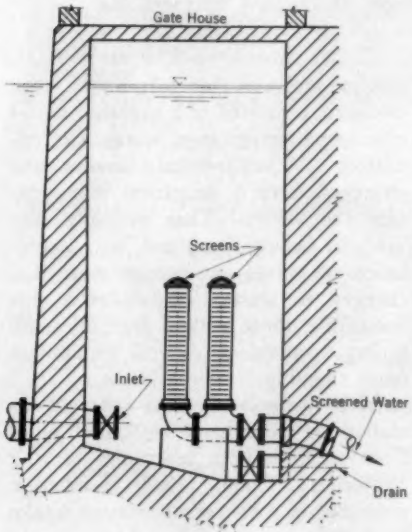


Fig. 1. Typical Vertical-Screen Gravity Installation

Water from the right-hand compartment may flow back through its well screen and thus backwash the screen, the screenings being disposed of through the drain.

the time and labor required to clean panel screens in an intake 60 ft deep. Time was so critical at certain periods of the year that a screen could completely clog with leaves before a parallel screen could be cleaned and put back in service. Because of the depth of the chamber, the isolation of the intake, power requirements, cost, and other considerations, a traveling water screen was considered impracticable. The hydraulically cleaned screen was found to clog at a slower rate than the old panel screens and could be cleaned very rapidly by manipulating two gates. A second advantage was that eels and fish could not slip by while screens were being changed, as frequently happens with panel or basket screens.

Design Variations

Naturally, later installations have shown considerable variation in design. The method obviously has many merits when used in connection with vertical well pumps that pump from rivers with a large stage variation. The first installation of this type was made at Monroe, La., where the stage variation of the Ouachita River is about 40 ft. Later a very interesting installation was made in Venezuela on the Orinoco River, which is subject to an extremely large stage variation. In both instances a shaft was dug to some distance below the minimum water level. Horizontal intake lines were laid in the river and terminated in a heavily constructed intake device. Vertical well pumps were installed inside of well casings which were built with well screens at the bottom. The casings and screens were enclosed in a chamber of steel and concrete. A pressure water connection was made to the inside of the casing that terminated in a well screen, and the outer enclosure was so arranged as to permit a velocity high enough to carry screenings in the annular space between the two casings, or through a separate pipe, and discharge them above water level. This general arrangement is shown in Fig. 2. It will be recognized immediately that this type of arrange-

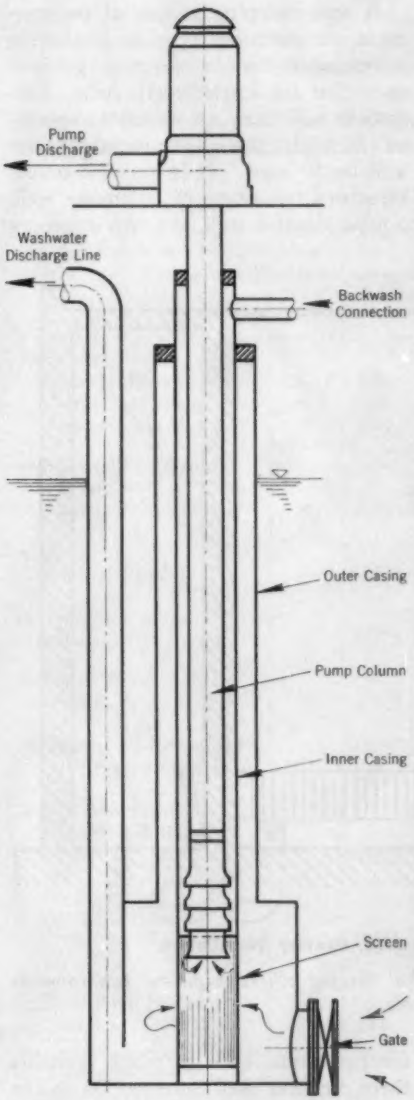


Fig. 2. Vertical Pump With Backwashed Screen

The pumping equipment may be installed entirely on the surface with this kind of screening arrangement.

ment is also capable of a considerable number of variations. The system works satisfactorily and has the obvious advantage that pumping equipment may be installed entirely from the surface.

Another modification that has been used is based on the compartment type of structure. In this kind of installation there are a common intake well, two screen wells, and a common outlet well. Water from the outlet well may flow by gravity or be pumped from the outlet well into the system. Figure 3 shows a typical layout for this type. In the particular one shown, the screens are placed horizontally, which is necessary when low-overhead conditions are encountered. There appears to be no operational disadvantage in placing the screens horizontally, although when ample headway is available the usual preference is to place the screen vertically, largely because of the smaller horizontal area required. The first horizontal screen installation was at the water-pumping station for a cement mill in Brazil. Another was constructed as a part of a gravity installation in St. John's, Newfoundland. The one shown in Fig. 3 is very similar to that made at St. John's.

A rather novel installation was made by the New Haven (Conn.) Water Co., during 1955. The only really convenient location for a pumping station was where a traprock cliff bordered the water source. This would have made a very difficult, expensive location for a conventional pumping station, because of the necessity of drawing the lake down a considerable degree. In order to avoid expensive cofferdamming and large rock excavations, it was decided to build a pumping station on a platform in the lake and use prefabricated, steel intake

chambers for the well pump. Four drilled-in caissons were constructed in the lake, and a concrete platform was built on the caissons. A steel box, which resembled the installation shown in Fig. 2, was prefabricated, launched on the lake, and floated into position alongside the pumping station. Water was admitted, and the intake portions of the station were sunk and pulled into their correct relative positions by means of cables. Three well pumps, each with a capacity of 4 mgd, were installed, and a superstructure was built over the station. A short bridge connects the station to the shore.

A new pumping station of the concrete compartment type is located in a reservoir that is about to go into operation for Little Rock, Ark. This station will have an ultimate capacity of 120 mgd, although the initial capacity will be 50 mgd. It is an all concrete structure consisting of an intake well, a pump suction well, and two screening compartments, each of which contains three vertical well screens, 36 in. in diameter and 10 ft in height. The well screens discharge into a compartment beneath the screen chamber, which in turn discharges into a large suction well into which extend two 25-mgd turbine pumps. The screens are back-

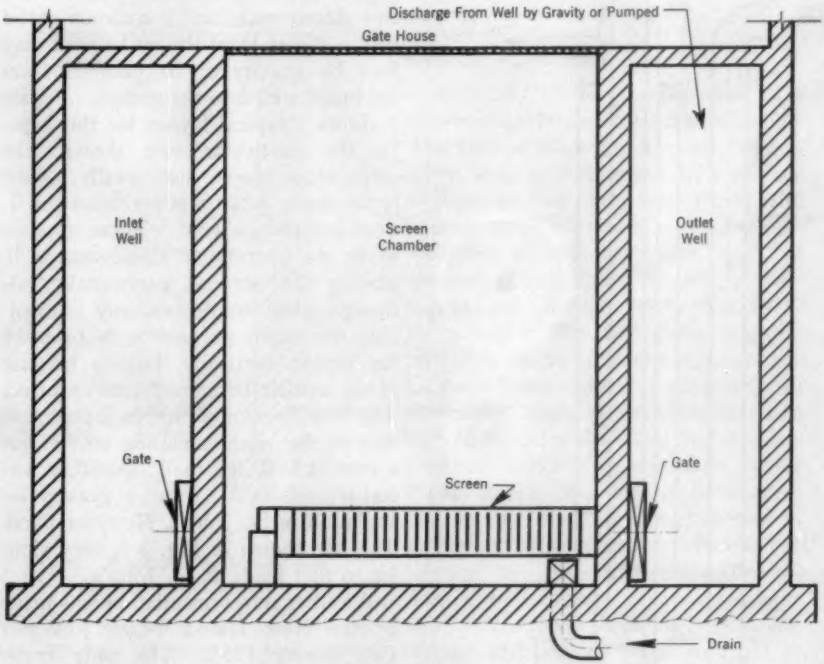


Fig. 3. Typical Horizontal-Screen, Gravity Installation

This kind of arrangement may have vertical screens where sufficient headroom is available.

washed in the same manner as those of the gravity installation first described, because in this particular system it is possible to discharge the drains of the screen chambers through the bypass conduit under the dam, but another variation is necessary when it is not possible to have a gravity discharge. Then the drains from the screen chambers are connected to the suction of a trash pump, and the backwash water and screenings are pumped out of and away from the pumping station.

In deciding on the opening size for intake screens, one's major consideration should be the eventual use of the screened water. Where the water receives no further treatment other than chlorination and goes directly into the mains, the screens generally have openings of from 0.04 to 0.06 in. Where the water is pumped to treatment plants and less need is evident for fine

TABLE 1

Hydraulically Backwashed Screens

Station	No. of Screens	Opening Width *in.*	Diameter *in.*	Length *ft*	Open Area *sq ft*	Flow Design *mgd*	Maximum Flow Velocity *fps*	Year Installed
Waterbury, Conn.								
Pitch Gate House	4	0.06	24	9	13.7	5	0.57	1941
Morris Gate House	4	0.06	24	9	13.7	5	0.57	1941
Wigwam Gate House	2	0.06	30	10	19.6	8	0.63	1955
Heppenstall–Eddystone Corp.								
Delaware River Intake	8	0.04	20	10	7.4	3	0.62	1942
Monroe, La.								
Ouachita River Intake	3	0.188	26	4	9.2	5	0.84	1950
Orinoco Mining Co.								
Orinoco River Intake	3	0.375	20	2	5.25	2	0.60	1952
Salvador, Brazil								
Cimentu Aratu	2*	0.125	12	6	8.15	1.5	0.28	1952
St. John's, Newfoundland								
Petty Harbour Intake	2*	0.06	16	9.5	10.3	4	0.60	1955
New Haven, Conn.								
Saltonstall Pumping Station	3	0.375	20	3.75	9.5	4	0.65	1956
Little Rock, Ark.								
Maumelle Pumping Station	6	0.375	36	10	47	20	0.67	1958
Bangor, Me.								
Flood Pond Pumping Station	2*	0.06	36	10	47	18	0.60	1958

* Horizontal screens

screening, the openings are commonly made $\frac{3}{16}$ or $\frac{3}{8}$ in. In any case, the customary design criteria have been for a flow velocity of not more than about 0.6 fps through the opening area.

It is possible to obtain considerable variation in the backwash rates by the way in which the backwashing is performed. If the intake and outlet gates are closed and the drain is opened, the chamber may be entirely emptied of water. If the gate on the screened water line is then opened, water under pressure will force the screenings from the screens and they will be discharged down the drain. It is usually not found necessary to use this procedure, however. If the gate on the screened water line is left open and the intake gate closed, the drain may be opened, and only a few inches of differential head between the feed water chamber and the chamber being washed will be sufficient to push the screenings off the screens. Sometimes it may be necessary to shut down the screened-water line to permit the screenings to drain out, but frequently the current induced by the flow of water will carry them through the drain without further assistance. Table 1 summarizes data on some typical installations.

Conclusion

This paper has described a method of screening surface waters that has been used successfully by the authors' firm over the past 20 years. It is a method having wide applicability in systems that involve withdrawal of surface water from reservoirs or other sources by gravity or pumping. Most of the installations made to date are for gravity systems or systems using vertical pumps. Although no hydraulically backwashed screens have thus far been used by the authors' firm as a part of horizontal pumping installations, some will undoubtedly be used in the future.

Determination of Synthetic Detergent Content of Raw-Water Supplies

Task Group Report

A report of Task Group 2662 P—Analytical Methods for Synthetic Detergents, presented on Apr. 24, 1958, at the Annual Conference, Dallas, Tex., by James C. Vaughn (Chairman), Asst. Chief Water Chem. Engr., South Dist. Filtration Plant, Dept. of Water & Sewers, Chicago, Ill. Other members of the task group were W. F. White, G. P. Edwards, H. P. Kramer, P. J. Weaver, George Flood, R. F. Falkenthal, R. W. Schmidt, and H. F. Laughlin.

SINCE the end of World War II, the synthetic detergent (syndet) market has expanded to the extent that today approximately 90 per cent of the washing products used in the American home are syndets. The most rapid rate of this expansion occurred in the first few years directly after the war; since that time, while the market continues to grow, it has slowed down considerably. Of the products sold for household use the all-purpose package brands comprise by far the largest part, while the liquid detergents and light-duty package brands, which are used for washing dishes and fine fabrics, make up the remainder. More than two billion pounds of these products are now sold for home consumption each year.

Concurrent with the dramatic rise in popularity of syndets a number of questions were raised as to their possible effects on water treatment processes. An AWWA Task Group was, therefore, formed in Sep. 1953 to consider the effects of syndets on water supplies. This task group, under the chairmanship of Paul D. Haney, presented its report in May 1954 (*1*). The report noted that a number of questions needed to be resolved, the most important of which related to analytical methods. A number of other areas of investigation were also pointed out. Since 1954 a good deal of work on various phases has been accomplished, and many of the questions raised have been clarified. A number of the incidents noted in the Haney report have not recurred, despite the fact that indicated syndet levels have been as high as before. An example of this is the Wheeling, W.Va., episode. There has been no repetition of the severe foaming condition which occurred there late in 1953. Also, although severe water shortages in the state of Kansas have resulted in higher concentrations of surface-active agents than in other parts of the country, no difficulty has been reported in treating the waters containing these concentrations. The only manifestation of the increased alkyl benzene sulfonate (ABS) content has been a tendency towards

slight frothing of the water as it is drawn from the taps, and this has been only a temporary problem.

Overall, the difficulties of assessing problems of these types have related to the problem of obtaining accurate, rather than misleading, analytical information.

Detergents

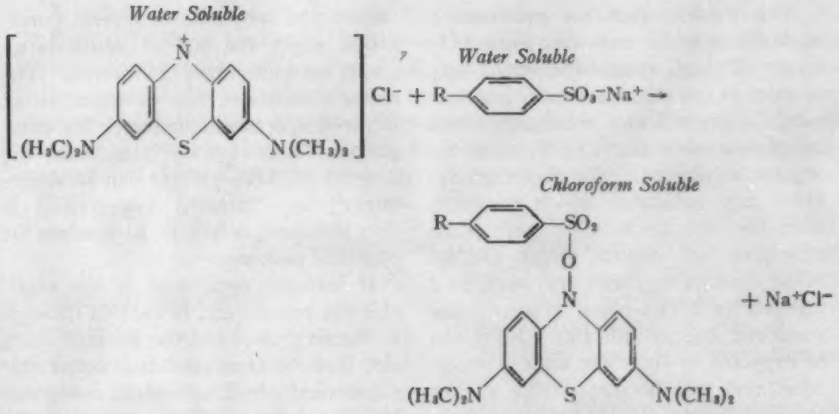
All syndets contain an organic, surface-active agent which has the important qualities of wetting out, dispersing, and emulsifying soil. Unlike soaps they are essentially unaffected by hardness salts, which is the basic reason for their wide popularity. In addition to the surface-active material, some household detergents may contain additional compounds, which are generally called "builders," such as complex phosphates and silicates. Products formulated to include these builder compounds as well as the surface-active agent are known as the all-purpose syndets, since they are equal to soaps in their ability to remove dirt from heavily soiled clothes.

When used in the home in a relatively concentrated washing solution, 2,000 ppm total product concentration, for example, all of the ingredients in a given syndet will work together to accomplish the desired cleaning job. When the washing is completed, however, and the washing solution is released down the drain to the sewer the combined action of these materials is completed and each individual component must be considered separately. For example, the effect of bacterial action on the surface-active portion would be entirely different from the bacterial action on the complex phosphate.

In considering possible problems which might be related to syndets, this discussion will concern itself solely with the problem of analyzing trace amounts of the surface-active-agent portion of the syndet which may be found in surface waters. The most widely used single compound of this type is the alkyl benzene sulfonate (ABS) derived from polymerized propylene. A number of studies have established that, in addition to being the most widely used surface-active agent, this material degrades more slowly than other surface-active agents used in detergent products. As a result, ABS is the specific material of this type most apt to be present in raw water supplies, if any at all is present.

ABS Analysis

At the time the Haney report (*1*) was made in 1954, the most widely used analytical method for ABS in raw-water supplies was the methylene blue process. This method has undergone slight variations and improvements since that date and is still by far the most widely used. The process depends on the formation of a blue-colored salt when methylene blue reacts with ABS. This salt is soluble in chloroform but not in water, whereas the dye and the ABS are soluble in water but not in chloroform. The color intensity of the dye in the chloroform is proportional to the concentration. This intensity is measured in a spectrophotometer and compared with standard solutions for apparent ABS content. The reaction between ABS and methylene blue can be represented:



The basic problem with the methylene blue process is that many naturally occurring substances also form extractable salts with methylene blue. The process may, therefore, show erroneous results. Both organic and inorganic compounds interfere with the determination of ABS. Some of the proved interferences can be predicted on the basis of chemical properties. Organic sulfates, sulfonates, carboxylates, phosphates, and phenols, which complex methylene blue, and inorganic cyanates, chlorides, nitrates, and thiocyanates, which form ion pairs with methylene blue, are among the positive interferences. Organic materials, especially amines which compete with the methylene blue in the reaction, cause low results. Positive errors are much more common than negative errors when determining anionics in water, however.

In the past few years a voluminous literature has been built up covering attempts to circumvent these interferences. Evans (*2*) in 1950 proposed extraction of the complex at two different acidities and extrapolation to a third to reduce interference in sewage samples. Some interferences were eliminated, but others remained.

In attempting to remove inorganic interferences, Degens and others (*3*) in 1953 used water washing of the $CHCl_3$ extract. Although this further improved the method some interferences still remained.

Longwell and Maniece (*4*) in 1955 proposed a modification in which the methylene blue complex was extracted from alkaline solution. In this way they avoided negative interferences due to nitrogenous material and positive interferences due to inorganic ions. Studies have again shown, however, that while some interferences are prevented, some remain, and the total of the positive interferences present, on samples so far tested, have been essentially the same as in the Degens method (*3*).

Moore and Kolbeson (*5*) in 1956 recommended substitution of methyl green for methylene blue, and extracted with benzene. The effects of different interferences are varied slightly but are not prevented by this method.

It is evident that the colorimetric methods now in use are subject to error. Though special conditions may prevent or reduce a particular interference, in general any substance which complexes with the dye to form an organic soluble salt will give high results; any substance which competes with the dye to complex with ABS will give low results. Any method based on similar chemistry, such as a titration in a two-phase system using a colored dye as indicator (*6–8*), can be expected to show the same interferences and will be inapplicable at low concentrations. This is the basic weakness of colorimetric procedures. The operator who obtains an apparent high concentration of ABS will not know how much of the result is due to ABS and how much to natural interferences. There are instances on record where raw-water samples containing essentially no true ABS showed apparent ABS levels as high as 1.5 ppm, all because of interfering materials.

Infrared Process

Recognizing the need for an improved analytical procedure, the syndet industry, through the Association of American Soap & Glycerine Producers, New York, developed a referee method (*9*). Through the use of infrared techniques this method can unequivocally establish the presence and amount of ABS in any given water sample. In the procedure, the water sample to be analyzed is passed through a column of activated carbon and the ABS is adsorbed onto the carbon. This concentrates the ABS and separates it from many interferences. ABS can be quantitatively collected from concentrations as low as a few parts per billion by this technique. The ABS is then desorbed from the carbon and subjected to several purification steps, the last of which is an amine extraction into chloroform. The amine complex is then examined in an infrared spectrophotometer. By comparison with known standards the amount of ABS present can be determined; an "infrared fingerprint" is also obtained definitely to confirm its chemical makeup.

If infrared equipment is not available the process can be carried through to the final step and the purified ABS can then be recovered and tested colorimetrically by the standard methylene blue procedure. This precludes the need for expensive and complicated equipment, which the majority of water treatment plants probably would not have.

The big drawback to the infrared method is that, compared to the methylene blue colorimetic process, it is fairly complicated and time-consuming.

Use of Both Processes

It is recommended that the water plant operator who is interested in the ABS content of his raw-water supply follow a two-step approach in analyzing for ABS content:

1. The operator should first analyze the sample by the methylene blue process. If the result of this analysis is low enough, no further analyses will be required, since in this case the sum of interferences plus true ABS content is such that ABS would not be a significant factor. Based on analyses obtained with the methylene blue procedure when no problems of any sort were observed, it is suggested that there would probably be no need to check if the apparent level is 1.0 ppm or so.

2. When the methylene blue result is high it becomes important to know how much is represented by true ABS and how much by interferences. It is recommended that the operator then analyze a sample by the infrared method. If infrared equipment is unavailable, a colorimetric "finish" can be used instead. If the problem is of sufficient importance, and the operator is unable to analyze by the infrared method, it is recommended that he request such analytical help through his state board of health.

A. Methylene Blue Process

1. General Discussion

1.1. *Principle.* This process depends on the formation of a blue-colored salt when methylene blue reacts with ABS. The salt is soluble in chloroform and the intensity of color is proportional to the concentration. The intensity is measured by making spectrophotometric readings in this solvent at a wavelength of 652 mμ. The method is applicable in the 0.025–100 ppm (as ABS) range.

1.2. *Interference.* Both organic and inorganic compounds interfere with the determination of ABS. Some of the proved interferences can be predicted on the basis of chemical properties. Organic sulfates, sulfonates, carboxylates, phosphates, and phenols, which complex methylene blue, and inorganic cyanates, chlorides, nitrates, and thiocyanates, which form ion pairs with methylene blue, are among the positive interferences. Organic materials, especially amines which compete with the methylene blue in the reaction, can cause low results. Positive errors are much more common than negative when determining anionics in water.

2. Apparatus

2.1. *Graduated cylinders,* 250 ml, 100 ml, 25 ml.

2.2. *Beaker,* 600 ml.

2.3. *Separatory funnels,* 500 ml.

2.4. *Volumetric flask,* 100 ml.

2.5. *Glass wool,* pyrex filtering fiber.*

2.6. *Spectrophotometer,* either Coleman Junior,† or Beckman Model B.‡ Refer to the instructions with the instruments. Calibration curves should be plotted by running a series of ABS solutions of known concentrations. Figure 1 shows an example of calibration curves for both types of spectrophotometer.

2.7. *Glass spectrophotometer cells.* For the Coleman, Selected Cuvettes, 6-300 A, 25 × 105 mm; for the Beckman, Cortex Absorption Cells, 5.00 cm.

3. Reagents

3.1. *Standard ABS for calibration.*§

3.2. *Chloroform,* cp grade.

3.3. *Sodium hydroxide,* either approximately *N* NaOH, or approximately 20 per cent NaOH.

3.4. *Sulfuric acid,* either approximately *N* H_2SO_4, or cp concentrated H_2SO_4.

* Manufactured by Corning Glass Works, Corning, N.Y.

† Manufactured by Coleman Instruments, Maywood, Ill.

‡ Manufactured by Beckman Instruments, Fullerton, Calif.

§ Obtainable from the Assn. of American Soap & Glycerine Producers, New York.

3.5. *Phenolphthalein,* 1 per cent in alcohol.

3.6. *Methylene blue chloride,* Eastman No. P573, or equivalent. Dissolve 0.1 g of methylene blue in 100 ml of distilled water. Transfer 30 ml of this solution to a 1-liter volumetric flask. Add 500 ml distilled water, 6.8 ml concentrated H_2SO_4, and 50 g of the monosodium phosphate. Shake until the solution is complete. Dilute to the 1-liter mark.

3.7. *Wash solution.* Add 6.8 ml of cp concentrated H_2SO_4 to 500 ml distilled water in a 1-liter flask. Introduce 50 g of monosodium dihydrogen phosphate monohydrate, ACS reagent grade, and shake until the solution is complete. Dilute to the 1-liter mark.

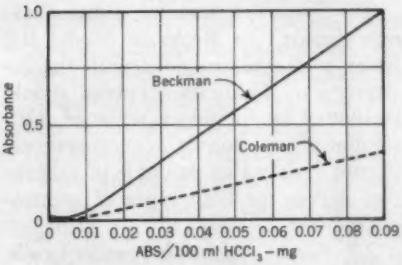


Fig. 1. Calibration Curves

This figure shows an example of calibration curves plotted with the Beckman and the Coleman spectrophotometers. These curves are expressed in terms of mg ABS as the abscissa and absorbance, or optical density, as the ordinate.

4. Procedure

4.1. *Preparation of calibration curve.* Prepare a standard solution by weighing an amount of the reference material equal to 1 g ABS on a 100 per cent active basis, dissolving in distilled water and diluting to 1 liter. Pipet 10 ml of this solution into a second 1-liter volumetric flask and dilute to volume with distilled water. Prepare a series of ten separatory funnels, with zero, 1, 3, 5, 7, 9, 11, 13, 15, and 20 ml of the dilute ABS solution, respectively. Add sufficient water to make the total volume 100 ml in each separatory funnel. Mg ABS (in 100 ml chloroform) = 0.01 × ml of standard solution; plot mg ABS against absorbance.

4.2. *Volume of sample.* The volume of the water sample to be tested is based on the expected ABS concentration:

Expected ABS Concentration—*ppm*	Sample Taken *ml*
0.025–0.08	400
0.08–0.4	250
0.4–2.0	100
2.0–10.0	20
10.0–100.0	2

If a sample of less than 100 ml is indicated, dilute to 100 ml with distilled water; if 100 ml or more is used, extract the entire sample.

4.3. *Procedure for testing process:*

a. Make the solution alkaline by adding *N* NaOH, using phenolphthalein as the indicator. Then acidify with *N* H_2SO_4 and transfer to a separatory funnel.

b. Add 10 ml of chloroform and 25 ml of methylene blue. Rock vigorously for 30 sec and allow the phases to separate. Excessive agitation may cause emulsion trouble. Some samples require a longer period of phase separation than others.

c. Draw off the chloroform layer into a second separatory funnel. Rinse the delivery tube of the first separatory funnel with a small amount of chloroform. Repeat the extraction three times, using 10 ml of chloroform each time. If the blue color in the water phase becomes faint and disappears

add 25 ml more of dilute methylene blue.

d. Combine all extracts in the second separatory funnel. Add 50 ml of wash solution and shake vigorously for 30 sec. Emulsions do not form at this stage. Allow to settle and draw off the chloroform layer through the glass wool into the volumetric flask. Repeat the washing twice more with 10 ml of chloroform each time. Rinse the glass wool and the funnel with chloroform. Collect the washing in the volumetric flask, dilute to the mark, and mix well.

e. Determine the absorbance of the solution at 652 mμ, using a glass cell against a blank of chloroform, according to the instructions furnished with the spectrophotometer.

5. Calculation

The total apparent ABS of the sample may be calculated by the formula:

$$\text{ABS (ppm)} = \text{mg/l ABS} = \frac{\text{mg ABS from calibration curve} \times 1{,}000}{\text{sample taken (ml)}}$$

B. Infrared Process

1. General Discussion

1.1. *Principle.* This process involves the collection and isolation of a few milligrams of ABS and its quantitative determination based on infrared absorption of an amine complex of the ABS. Though lengthy this method is specific and accurate for low concentrations in water. When an infrared spectrophotometer is not available a colorimetric "finish" can be substituted by recovering the purified ABS and determining how much is present by the methylene blue process.

1.2. *Application.* This process is applicable to raw water samples only, not to sewage or industrial wastes.

1.3. *Precaution.* Most samples contain both solid and liquid phases, and the ABS is highly concentrated in the solid phases. For accurate analyses it is essential that the solids be either representatively sampled or excluded.

2. Apparatus

2.1. *Carbon adsorption tube.* This tube is a glass column, about 2 × 24 in., containing 100 g of carbon. Screens of stainless steel or brass, about 30 mesh, divide the carbon into sections of 20, 30, 40, and 10 g (see Fig. 2).

2.2. *Volumetric flasks,* either 2 or 5 ml.

2.3. *pH meter.*

2.4. *Buchner funnel,* 500 ml, medium porosity, sintered glass.

2.5. *Precaution.* All glassware used in the infrared process must be free of contamination. A thorough rinse with 1:1 hydrochloric acid must be used to remove adsorbed ABS.

3. Reagents

3.1. *Standard ABS for calibration.**

3.2. *Carbon:*

a. Solution for extracting carbon: 500 ml thiophene-free benzene, 420 ml methanol, and 80 ml approximately 0.5 *N* alcoholic KOH.

b. Test for impurities in carbon: Extract 100 g of carbon by boiling 1 hr in 500 ml of thiophene-free benzene plus 500 ml of methanol. Filter the carbon, wash with 100 ml of methanol, add the washings to the remainder

* Obtainable from the Assn. of American Soap & Glycerine Producers, New York.

of the solvent mixture, evaporate to dryness on a steam bath, and weigh. The residue consists of soluble organic impurities and should be less than 10 mg, not including any residue from the solvent.

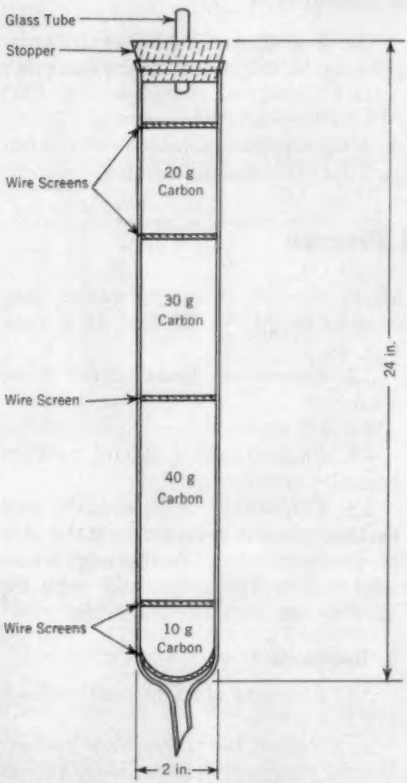


Fig. 2. Carbon Adsorption Tube

This tube is made of glass and contains 100 g of carbon. It is used in the infrared process for determining ABS in water.

3.3. *1-methylheptylamine,* Eastman No. 2439.

3.4. *Solution for extracting ABS:* 400 mg (20 drops) of 1-methylheptylamine in 400 ml of $CHCl_3$. This solution should be prepared fresh daily.

3.5. *Buffer solution:* Dissolve 6.8 g KH_2PO_4 in 1 liter of water. Adjust to pH 6.8–6.9 with 25 per cent KOH.

3.6. *Activated carbon,* unground.*

4. Procedure

4.1. *Preparation of calibration curve.* Place 25 mg of standard ABS in a 5-gal glass vessel and dilute with about 4 gal of distilled water. Mix thoroughly and, using synthetic rubber-like tubing, siphon the entire solution through the carbon column. Repeat with 20, 15, 10, 5, and zero mg ABS. Make two calibration curves by plotting the ABS added as the abscissa and the absorbances of the maxima at 9.6 and 9.9μ as the ordinate. The baseline technique is best used in determining the absorbance of the maxima.

4.2. *Volume of sample.* Estimate the concentration of ABS present in the sample. Calculate the volume of sample required to supply 10–25 mg ABS. If 2 liters or less, measure about 10 g of granular activated carbon into a 2-liter glass-stoppered graduated cylinder, add the sample, and shake well for 2 min. Filter on a medium-porosity, sintered-glass Buchner funnel. If more than 2 liters of sample is required, pass through the column of the carbon at the rate of 10 gph, or less.

4.3. *Procedure for testing process:*

a. Transfer the carbon from the Buchner funnel or column, treating the sections separately, to porcelain evaporating dishes and dry at 105–110°C. Brush the dried carbon from each dish into separate 2-liter bottles or flasks with standard-taper necks and add 1

* Obtainable from the West Virginia Pulp & Paper Co., New York.

liter of 1:1 benzene-alcohol which is 0.04 *N* in potassium hydroxide. Add boiling chips and reflux under an air condenser for 1 hr. Filter with a vacuum through a medium-porosity, sintered-glass Buchner funnel, draw off all liquid, release the vacuum, and add 100 ml of methanol. Stir with a glass rod and draw off the wash with a vacuum. Wash a second time with another 100-ml portion of methanol. Return the carbon to the flask, add solvent as before, and reflux for 1 hr. While making this second extraction, evaporate the solvent from the first extract and washes. Carry out this evaporation in a 2-liter beaker on a steam bath. A gentle stream of nitrogen or air on the surface will hasten the evaporation.

b. Filter off the second extract and wash the carbon as before. Add the extract and washes to the beaker containing the first extract. Discard the carbon. Evaporate sufficiently to combine in one beaker the extracts from the 20-, 30-, and 40-g sections of the column. Treat the extracts of the 10-g section separately throughout the entire procedure. After the solvent has been removed, take up the residue in 50 ml of warm water. Transfer to a 250-ml standard-taper Erlenmeyer flask. Rinse the beaker with 30 ml of concentrated hydrochloric acid and add slowly to the flask. Carbon dioxide is evolved. Rinse the beaker with 50 ml of water and combine with other washings in the flask. Reflux under an air condenser for 1 hr.

c. Remove the condenser and continue boiling until the volume is reduced to 20–30 ml, transfer to a steam bath, and evaporate to near-dryness. A jet of air directed on the surface of the liquid will greatly aid evaporation. Take the solids up in 100 ml of water and neutralize with a 5 per cent sodium hydroxide solution to a pH of 8–9. Extract once with 50 ml of petroleum ether. A maximum of 70 per cent ethanol may be added, if necessary, to break emulsions. Wash the petroleum ether twice with 25-ml portions of water, discard the petroleum ether layer, and add the washes to the aqueous solution. Boil off any alcohol that was added.

d. Cool and transfer quantitatively to a 250-ml separatory funnel. Neutralize by adding dilute sulfuric acid until just acid to litmus. Add 50 ml of buffer solution and 2 drops of 1-methylheptylamine and shake vigorously. Add 50 ml of 1-methylheptylamine-chloroform solution and 25 ml of chloroform. Shake for 3 min and allow the phases to separate. If an emulsion forms, draw off the lower (chloroform) phase, including any emulsion, and filter through a plug of glass wool wet with chloroform, using suction if necessary, into a 250-ml separatory funnel. Draw off the chloroform phase into a 400-ml beaker and return any aqueous solution to the first separatory funnel. Wash the glass wool plug with 10 ml of chloroform and add to the chloroform extract.

e. Make an additional extraction with 50 ml of 1-methylheptylamine-chloroform solution and 25 ml of chloroform. Shake 2 min and separate the phases (see *d*), if necessary. Extract a third time with 5 ml of the amine solution and 45 ml of chloroform and a fourth time with 50 ml of chloroform. Evaporate the combined chloroform extracts on a steam bath. With 10 ml of chloroform, quantitatively transfer the residue to a 50-ml beaker using three 5-ml portions of chloroform as rinses. Evaporate to dryness and continue heating on the steam bath for

30 min to remove excess amine. Take up the residue in about 1 ml of carbon disulfide or carbon tetrachloride and filter through a plug of glass wool in a funnel stem (2-mm bore) into a 2- or 5-ml volumetric flask. Dilute to volume through the filter with several rinsings from the beaker.

f. Transfer a portion of the sample to an infrared cell without further dilution. Run the infrared absorption curve from 9.0 to 10.5 μ against a solvent blank. Measure the absorbance of the 9.6- and 9.9-μ peaks, using base lines from 9.5 to 9.8 and 9.8 to 10.1 μ. From appropriate calibration curves calculate the concentration of ABS in the original sample. Report the values based on each wavelength separately. If infrared equipment is unavailable, a colorimetric "finish" can be used. The sulfonate-amine complex can easily be broken by boiling with aqueous alkali. After the amine has been boiled off, as indicated by a lack of amine odor, and suitable dilutions are made, colorimetric results should check well with infrared values.

g. Evaporate a 0.5–1.0-ml portion of the ABS solution on a sodium chloride flat. Record the absorption spectrum from 2 to 15 μ for positive qualitative identification of ABS.

Precaution. The carbon adsorption should be used on all samples. It separates the ABS from many of the materials present and reduces emulsion difficulties.

Note. From 10 to 50 ml of water may be lost through a 60 × 1 cm air condenser during acid hydrolysis. This loss, while not affecting the hydrolysis, reduces the amount of water that needs to be boiled off after removal of the condenser.

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Synthetic Detergents as a Factor in Water Softening Economics

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A paper presented on Apr. 23, 1958, at the Annual Conference, Dallas, Tex., by William W. Aultman, Vice-Pres., James M. Montgomery, Cons. Engr., Pasadena, Calif.

BEFORE the advent and widespread use of synthetic detergents for household cleansing purposes, several authorities (*1–6*) had demonstrated that the savings realized by the individual householder from the use of soft water were materially greater than the cost of municipally softening hard water. The major item used in the comparative evaluation was the cost of soap. Its required use varies directly with the hardness of the water, and soap is the one soft-water benefit to which a dollar value can be readily assigned. It is a question, however, whether these economic advantages still prevail now that the synthetic detergents are rapidly replacing soaps as cleansing agents in the home.

The definition of a hard or a soft water is not precise. A recently published textbook (*7*) uses a definition generally accepted by water authorities:

> Waters containing less than 50 mg/l of hardness are considered soft; those containing more than 100–150 mg/l, the magnitude depending upon the regional composition of available water supplies, are considered hard.

Municipal treatment plants seldom soften a water to less than about 85–100 ppm because water that is much softer than this has several disadvantages: It does not rinse away suds readily, may seem slippery, and may be quite corrosive. Moreover, a large percentage of the supply is used for lawn and garden sprinkling, toilet flushing, and other purposes where the hardness is not a concern.

Detergents are cleansing aids, soap being one of the oldest and best-known detergents. The newer types of "soapless soaps" are called synthetic detergents or "syndets." A soap is a sodium or potassium salt of a fatty acid, made by combining an alkali with a fat; syndets are complex chemical compounds made from petroleum, fats, or oils. Builders may be added to soaps and syndets to give them greater cleaning powder or to give them some water-conditioning properties, or both. These builders are alkalies such as carbonates, silicates, and phosphates (*8*).

Syndets

The major item stressed in the publicity for the syndets has been that they perform just as satisfactorily in hard water as in soft. This is not correct; it is this statement that has led to the belief that water softening is no longer needed.

The effect of hard water on detergent use is recognized by the chemists who manufacture syndets, as shown by

a statement in a recent technical article on the subject (*9*):

> One virtue of synthetic detergents is that, in general, they give very soluble calcium and magnesium salts. It was expected that the detergency of synthetic detergents would not be adversely affected by hard water. However, the shift from soap to synthetic detergents did not entirely eliminate the hard water problem. Detergents provided only an apparent, partial solution by not forming insoluble hard water salts. Later, it was found that the addition of phosphate to synthetic detergents was necessary for acceptable detergency in hard water.

The phosphate is added as a sequestering agent: the harder the water, the more phosphate required.

The amount of soap required to accomplish satisfactory cleansing in waters of different hardness can be ascertained readily, because soap does not clean until a lather is formed, and a lather does not form until the soap has reacted with the calcium and magnesium in the water. This reaction is what forms the "curd" when soap is used in hard water. The syndets do not react in the same way. Syndets dissolve readily in water which is hot or cold, soft or hard, and they do not form a "curd" in hard water. Their pronounced ability to emulsify oil and grease is an advantage in cleaning clothes. Some syndets form suds readily just as soap does, whereas others clean with little or no suds. The quantity of suds produced is not indicative of cleansing ability and frequently more suds are produced in hard water than in soft. Consequently, it has been difficult to evaluate comparatively the cleansing properties of the syndets in waters of differing hardness, or even the properties of the many different syndet formulations.

The method that has been developed for syndet evaluation is to ascertain the "per cent soil removal" from so-called standard, soiled cloth under different test conditions. This method has been fairly satisfactory, but is not truly representative of normal household washday conditions, for there are many different types of soil and it has been found that some syndets work very well with some kinds of soil and not so well with others. The chemists are, therefore, reluctant to release any comparative-evaluation data because a satisfactory standard of comparison has not yet been established.

An investigation which has included: [1] a survey of the technical literature, [2] correspondence with manufacturing and research chemists from the major producers of household syndets and private and governmental research technicians, and [3] personal interviews, has shown conclusively that water hardness does affect the efficiency of the syndets used in the home. This is borne out by such statements as:

> 1. Practically, all synthetic-detergent laundering products on the market today contain a soil-suspending agent. This agent is designed to prevent the redeposition of removed soil onto the fabric being laundered. These agents are good but not perfect. In the case of hard water, the magnesium and calcium ions present aggravate redeposition of soil, and it is for this reason that the detergents do not perform quite as well in hard water as in soft. As might be expected, this situation becomes worse as the hardness of the water increases (*10*).
>
> 2. Unfortunately, detergents are not the complete answer. At first, they go right to work on the dirt, breaking it up and floating it away. But hardness ions in the water interfere with these tiny particles and cause some of the dirt to be redeposited on the fabric. Although

the hard water rinse can carry away the floating particles, it can't budge the redeposited dirt. The real answer is soft water to begin with, for both soap and detergent (*11*).

3. For similar cleaning jobs, however, a greater amount of synthetic detergent is needed in hard water than in soft (*12*).

4. Assuming average conditions—meaning about 7 grains hardness, moderate soil, and a 6–8 lb-load of clothes—we feel that a 0.2 per cent concentration of detergent will give satisfactory results and is a realistic concentration toward which to aspire. In soft water with all other conditions equivalent, 0.15 per cent concentration would probably give equal cleaning; and in 21-grain hardness, again all other conditions equivalent, probably 0.3 per cent concentration would be required for equal cleaning (*13*).

5. In washing clothes in a washing machine, it takes approximately twice as much product in water, 21 grains per gallon (360 ppm) in hard as in soft water. The amount of product involved is approximately one normal-size carton of all-purpose detergent (20–22 oz) per week for an average family using water 7–10 grains per gallon (120–170 ppm) hard. . . . You probably will not be far off if you assume that softening fairly hard water would save the average family one-third to one-half a carton of detergent (popular size, 20–22 oz) per week (*14*).

Soap vs. Syndets

The best specific, factual data presently available pertaining to the relative amounts of syndets and soaps required in hard and soft water were obtained by a cooperative study made in 1955 for the Dow Chemical Co. and the magazine, *Woman's Home Companion* (*15, 16*). This study was made by the Warren family of West Lafayette, Ind., under the supervision of Purdue University. Under closely controlled conditions this family of five operated for four 6-week periods as follows:

1. First 6-week period using hard water (360–410 ppm) with syndets as principal cleansing agents
2. Second 6-week period using hard water (360–410 ppm) with soap as principal cleansing agent
3. Third 6-week period using soft water (zero–10 ppm) with syndets as principal cleansing agents
4. Fourth 6-week period using soft water (zero–10 ppm) with soap as principal cleansing agent.

The results of this study with respect to the use of soap and syndets are summarized in Table 1 and are shown graphically in Fig. 1. The same types of shampoo, toilet bar soap, dishwasher water conditioner, and scouring powder were used during all test periods. In 1955, when these tests were made, the syndet-type bar soaps were not so available as they are at present (Apr. 1958).

These data show that a larger quantity of syndets and soap are required to obtain proper cleansing in hard water than in soft water. They also show that the relative quantity of syndets required in hard water is proportionately not so great as the quantity of soap required.

At the start of each test period the Warren family was supplied with new dish towels, children's T-shirts and trunks, men's white shirts and bedding. Other items furnished were glass double boilers, tea kettles, glassware, and silverware. During the 6 months of the study Mrs. Warren, besides recording cash expenditures, recorded the time required for the various household tasks and noted the appearance of the family clothing, linen, china, glassware, and silverware. She found that she saved time, effort, and money when she

used soft water. A pictorial record showed clearly the improved appearance of the articles washed in soft water over those washed in hard water.

double boilers would indicate, however, that with the hard water, the hot water heater would tend to scale rapidly and thereby lose its heat-transfer efficiency

TABLE 1

Consumption of Cleansing Agents in Hard versus Soft Water

Use	Hard Water Period		Soft Water Period		Annual Difference		
	Amount Used in 6-week Test Period oz	Amount Used in 1 Year oz	Amount Used in 6-week Test Period oz	Amount Used in 1 Year oz	Quantity oz	Unit Price $/oz	Annual Cost $
	Syndets						
Dishes, hand	36.00	312.00	5.00	43.00	269.00	0.01526	4.10
Laundry, machine	138.00	1196.00	52.00	450.00	746.00	0.01400	10.44
Laundry, hand	6.00	52.00	1.33	11.50	40.50	0.01611	0.65
Cleaning	40.00	347.00	14.00	121.00	226.00	0.01526	3.45
Shampoo	3.44*	14.90	2.44*	10.60	4.30	0.30800	1.33
Shampoo	15.00*	65.00	9.40*	40.70	24.30	0.14285	3.48
Bar	21.75†	94.20	13.00†	56.30	37.90	0.13500‡	5.12
Dishwasher	92.50*	400.80	37.00*	160.30	240.50	0.01958	4.71
Scouring	47.00*	203.70	37.00*	160.30	43.40	0.00890	0.38
Annual cost		$63.90		$30.24			$33.66
	Soaps						
Dishes, hand	38.25	331.50	3.75	32.50	299.00	0.02274	6.80
Laundry, machine	303.00	2626.00	77.00	667.00	1959.00	0.01366	26.76
Laundry, hand	7.50	65.00	1.50	13.00	52.00	0.02320	1.21
Cleaning	27.00	234.00	14.00	121.00	113.00	0.01260	1.43
Shampoo	3.44*	14.90	2.44*	10.60	4.30	0.30800	1.33
Shampoo	15.00*	65.00	9.40*	40.70	24.30	0.14285	3.48
Bar	21.75†	94.20	13.00†	56.30	37.90	0.13500‡	5.12
Dishwasher	92.50*	400.80	37.00*	160.30	240.50	0.01958	4.71
Scouring	47.00*	203.70	37.00*	160.30	43.40	0.00890	0.38
Annual cost		$84.13		$32.91			$51.22

* 12-week period.
† Bars of soap in 12-week period.
‡ Unit price per bar.

No attempt was made in this study to determine the effect of the hard or soft water on the plumbing fixtures and piping. An examination of the photographs of the teakettles and in a short time. This would increase the cost of operation appreciably.

The development of various types of syndets for specific and general purposes continues. It is not known what

the future may bring in the way of new and better syndets that might provide good cleaning properties for all materials and be less affected by the hardness of the water supply. With present knowledge, however, it appears that builders will continue to be required as additives to syndets to compensate for increased water hardness, and that the cost of cleaning when using hard water will continue to be greater than when using soft water.

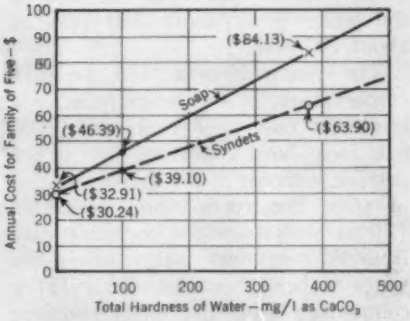

Fig. 1. Effect of Water Hardness on Cost of Cleansing Agents

These data compare the annual cost of soap and syndets in hard vs. soft water. This study was made in the summer of 1955. At 1958 prices these costs would be increased about 10 per cent.

Cost of Water Softening

The cost of water softening must be established before it can be determined whether, with the advent of the syndets, softening continues to be economically desirable.

Studies made and reported by T. E. Larson of the Illinois State Water Survey have established the relative cost of softening water in municipal treatment plants and by home-owned and home-serviced softeners (*5, 17*). These studies also show the corresponding relative cost of soap to accomplish the same degree of softening. It is shown that municipal treatment seldom softens water to a total hardness of less than 85 ppm, while both the home-owned and home-serviced units soften the water to a nominal hardness of zero.

The relative costs, as developed by T. E. Larson, are shown in Table 2. Based upon the smallest cost reported, which is for salt for softening 85-ppm hardness water in home-owned units, the relative costs of the other methods or degrees of hardness are shown as a ratio to this smallest cost. An examination of this table shows that municipal softening is the cheapest, even when further softening to practically zero hardness is done by household-type softeners.

TABLE 2

*Comparative Costs of Softening Methods**

Method	Initial Hardness—ppm			
	85	250	340	510
Municipal (to 85 mg/l)		2.0	2.7	4.0
Home-owned (salt cost)†	1.0	3.0	4.0	5.7
Home-serviced	10.0	17.5	23.0	34.0
Soap	2.6	5.8	7.6	10.8

* Shown as ratio to lowest cost per given unit of water volume.
† Not including amortization of softener.

The results of a survey by one of the soft-water service companies on the distribution of installations of the rental type of unit are shown in Table 3 (*17*). The data in this table show clearly that municipally softened water would benefit those with low and medium incomes more than those with high incomes, because 90 per cent of those with high incomes presently receive soft-water service. The soft-water

service companies and their customers would also benefit from municipal softening. Not only is the major portion of the hardness removed in the municipal plant, but also any iron, manganese, turbidity, color, and odors are generally removed.

The cost of water softened in a municipal treatment plant is variable, depending upon the type of hardness present—carbonate or noncarbonate—cost of chemicals, operating costs, interest charges, amortization of the capital investment, and size and type of treatment plant.

The cost properly chargeable to softening would be materially different for: [1] water requiring coagulation and filtration in any event, with softening added as a refinement; and [2] clear, iron-, manganese-, color-, and odor-free well water that would normally not be filtered except in conjunction with the softening process. In the first case, only the softening chemicals and a small amount of additional plant operation and facilities required for softening should be charged to the cost of softening. In the second case, all chemicals and all plant operation, including interest and amortization, should be charged to the cost of softening. In the first case, the cost of softening would normally be less than 3 cents per 1,000 gal. In the second case, the cost would normally range from something less than 6 cents to possibly 10 cents or more per 1,000 gal, depending upon the type of treatment and the type and capacity of the softening plant. The cost of construction of a large treatment plant is less per million gallons of capacity than for a small-capacity plant. A charge of 7 cents per 1,000 gal should be ample to cover all costs of softening in a plant of 30-mgd or greater capacity when reducing the total hardness of the water from about 380 ppm to about 100 ppm.

TABLE 3

Distribution of Rental-Type Softening Units

Annual Buying Income	Spending Units %	Rental-Type Softeners Installed %	Families in Bracket Receiving Soft-Water Service %
Greater than $7,000	6	27	90
$2,000–$7,000	64	57	18
Less than $2,000	30	16	11

The reasonableness, and probable conservatism, of this assumption of a treatment cost of 7 cents per 1,000 gal, have been confirmed by: [1] a detailed estimate of the theoretical cost of plant construction and operation, [2] an analysis of the operating data from 86 treatment plants where the water is being softened (*18*), [3] a comparison with the total treatment costs as developed in a recent study (*19*), and [4] a comparison with the actual annual cost of operation of a large softening and filtration plant.

The average charge made (total revenues divided by total water sales) for the water delivered in the 86 communities where softening was reported in 1955 was 21.5 cents per 1,000 gal. This included all costs for production, softening, distribution, accounting and billing, administration, capital charges, new construction, and surplus. The systems reported ranged in water deliveries for 1955 from less than 1 to 180 mgd; the average was less than 15 mgd. The hardness of the water, natural and softened, was not reported, but would vary considerably. Analyses have shown that in municipal water service the costs for pumping, distribution, accounting and billing, ad-

ministration, capital charges, and surplus are generally at least 75 per cent of the total revenues received. On this basis, the cost of softening would average not more than about 5.4 cents per 1,000 gal for the 86 communities reported.

The data compiled by Orlob and Lindorf (*19*) show that the total cost of treatment in the California area for a 30-mgd plant is approximately 4 cents per 1,000 gal. The type of treatment is not defined, but is assumed to be coagulation, sedimentation, and filtration only. The additional cost for softening chemicals and facilities would not exceed 3 cents per 1,000 gal, making an indicated total cost of not more than 7 cents per 1,000 gal.

The actual costs of operation of the 200-mgd water softening and filtration plant of the Metropolitan Water District of Southern California, located at LaVerne, Calif., are shown in Table 4. The salt for regeneration of the zeolite at this plant was purchased in 1955–56 at an unusually low price of $5.30 per ton delivered. If this cost were doubled, which would bring it to about the normal price for such salt elsewhere, the unit costs in Table 4 would be increased 0.878 cent per 1,000 gal to a total unit cost of softening of 3.668 cents per 1,000 gal.

It appears evident, therefore, that the assumed costs for softening in a municipal plant of 3–7 cents per 1,000 gal are reasonable averages to use for computation. (The lower figure applies only when treatment facilities are required to produce a satisfactory water even without softening.)

Residential Water Consumption

The total amount of water consumed by a family will vary greatly depending upon the size of the family, geographical location of the home, size of lot and type of landscaping, season of the year, and general standard of living of the family. Statistical studies made by the US Bureau of Census (*20*) show that there are approximately 3.5 persons per household on the average in the United States. Another study (*18*) shows that the average (median) residential water use in 86 cities in the United States served by publicly owned utilities was 68,000 gal per year per family in 1955. (These are not the same 86 communities used in the study of softening costs.) Based upon the household size of 3.5 persons per family, this average residential water use would amount to 53 gpcd. This figure agrees quite well with the per capita use reported in special studies made in the Illinois area (*21, 22*). In the far west and southwest water consumption generally is considerably higher than in the Illinois area because of the warmer climate, the larger landscaped areas around the homes, and the low summer rainfall. In Los Angeles residential water use only, apart from all other uses, amounted to 122 gpcd in 1956–57 (*23*). Actual water-meter record analysis of the residential use in other Southern California communities indicates that the per capita water consumption is even higher in certain localities.

Economic Aspects of Softening

Special investigations were made by the Purdue University Experiment Station and the Michigan State Department of Health to determine what drawbacks there were, if any, to the use of hard water in the home which the use of syndets cannot overcome (*2*). Estimated national averages

based on the results of these investigations indicate that:

1. A 25 per cent saving is realized on fuel for heating soft water by eliminating deposits of scale which retard heat flow.

2. An 18 per cent saving on repairing, cleaning, and replacing plumbing that is caked with scale is realized.

3. Fabrics show 25 per cent less wear and tear in soft water.

4. Soft water saves 16 per cent wear and tear on utensils.

5. Food cooked in soft water retains its natural color and appearance, and its digestive qualities. In making tea and coffee it takes 50 per cent less leaves or grounds in soft water than in hard.

6. Soft water for skin care provides less possibility for skin dryness and irritation. Bathtubs do not develop the severe "bathtub ring" and expensive bubble bath preparations are unnecessary. Toilet bars, which are still largely soaps, do not cause lime soap deposits that must be removed by scouring powder and scrubbing. Shaving blades last 20 per cent longer.

These percentages and favorable results will vary with the actual degree of hardness of the water. These results are for water approaching zero hardness, which is the quality of water obtained from the individual household water softener or from rental-type, home-service units. Municipally softened water with a total hardness of 85–100 ppm is still, comparatively, many times better than natural water with 300–500 ppm hardness before treatment.

TABLE 4

Description and Operating Costs of Softening and Filtration Plant, Metropolitan Water District of Southern California

Design capacity:	200 mgd
Type:	lime-zeolite softening and filtration
Total cost of plant*:	$7,662,980
Method of financing:	50-year bonds at 4% interest
Total water softened, 1955–56:	55,600 mil gal; average, 152 mgd
Average hardness reduction, 1955–56:	220 mg/l (natural water, 361 mg/l, finished water, 141 mg/l†)

Items	Operating Costs	
	Per Year—$	Per 1,000 gal—*cents*
Chemicals, power, waste water	794,284	1.426
Operation and maintenance	306,692	0.551
Employees' retirement	14,632	0.026
Total operating cost	1,115,608	2.003
Interest and amortization	356,712	0.641
Reserve for replacement	81,081	0.146
Total cost of softening	1,553,401	2.790

* Exclusive of land.
† Normal softened water hardness is 125 mg/l. Higher annual average is the result of operating the plant in the summer as much as 67 per cent above its designed capacity.

It is difficult, if not impossible, to attach a dollar value to many of the savings which are a result of water softening but the savings definitely exist, and the total is of considerable magnitude. A dollar value can be placed on the saving of soap or syndets by the use of soft water (see Table 1).

If the water used by a family were softened in a municipal softening plant from a natural water hardness of 380 ppm to a hardness of about 100 ppm a considerable saving would result. Assuming the United States average residential water use is 53 gpcd, based upon the data from the 86 cities discussed, a family of five would use a total of 96,725 gal per year for all purposes around the home. At the indicated average cost of 7 cents per 1,000 gal for softening the added cost for softening these 96,725 gal of water would be $6.77. The annual costs of syndets for cleansing, as shown in Table 1, were:

When using 380-ppm hardness water	$63.90
When using zero hardness water	$30.24
Annual saving	$33.66

If municipally softened water were provided, the water would have a hardness of about 100 ppm. The quantity of syndets or soap required when using this water would be closely proportional to the relative hardness of the water. Therefore, the annual cost of the syndet cleansing agents under these conditions would be approximately:

When using 380-ppm hardness water	$63.90
When using 100-ppm hardness water	$39.10
Annual saving	$24.80

This indicated saving is at 1955 costs for cleansing agents. At 1958 costs, the saving would increase about 10 per cent to a total of $27.28 per year.

The annual net saving that a family of five could realize from the municipal softening of the domestic water supply from its natural hardness of 380 ppm to a total hardness of about 100 ppm would be:

Saving in cost of syndet cleansing agents by using 100-ppm hardness water rather than 380-ppm hardness water	$27.28
Cost of municipally softening all water used by a family of five	$ 6.77
Net saving in cost of syndet cleansing agents per family of five	$20.51

For the average United States family of 3.5 persons, this net saving, solely in the cost of syndet cleansing agents, would be $14.35 per family per year. The corresponding net saving when using soap as cleansing agents would be about $24.30 per family per year. When a fair dollar value is placed on the other benefits derived from the use of soft water the total net saving would probably be at least twice the savings indicated for the syndets alone. The saving would thus approximate at least $30 per year for the average family of 3.5 persons. When soap is used alone, this would increase to about $40 per family per year. For a city of 35,000 persons, these savings would amount to somewhere between $300,000 and $400,000 per year, depending upon the ratio of use of the syndets to soap.

If residential water consumption were as high as 122 gpcd, the cost of municipal softening per family would increase, but the net savings for syndets alone would still be approximately $8.20 per year for a family of 3.5 persons. The other less tangible savings would be the same as, or greater than, estimated in this discussion, so the total net saving for consumers using 122

gpcd and syndets as cleansing agents would be about $24 per year per average family. The corresponding figure when using soaps as cleansing agents would be about $34 per year per family.

Summary

It is evident from the analysis of the facts that the advent of the synthetic detergents has not changed the economic desirability of water softening. The consumer will save an appreciable amount of money each year if hard water is municipally softened, even though he should decide to soften the water further by rental-type or household cation-exchange softeners. The actual amount of saving realized will depend upon the: [1] average per capita water consumption, [2] hardness of the raw water, [3] hardness of the softened water, [4] total cost of softening, [5] relative proportionate use of syndets and soap, [6] cost of syndets and soap, and [7] cost of plumbing facilities and services.

The examples cited indicate an annual net saving of about $24–$40 per average family of 3.5 persons when softening water in a 30-mgd treatment plant from a total hardness of 380 to 100 ppm. The range of saving will depend upon the ratio of syndets to soap used and upon the per capita consumption of domestic water.

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Discussion

Thurston E. Larson

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The writer is essentially in agreement with the conclusion that municipal softening plants can provide the best and most economical means of hardness reduction. In any case, esthetic considerations as well as savings, even apart from savings in syndets and soaps, probably far outweigh the costs of hardness reduction.

The data in this field are still, however, insufficient. Certain aspects of the problem, as presented by W. W. Aultman, appear to require further discussion.

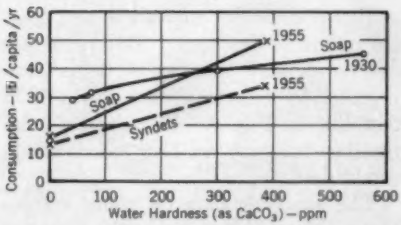

Fig. 2. Soap and Syndet Consumption versus Water Hardness

These data show consumption of soap and syndets in 1930 and 1955 related to hardness of the water.

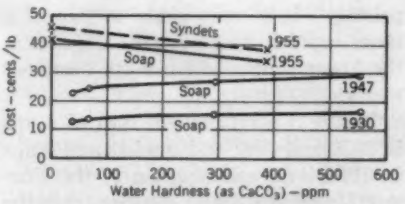

Fig. 3. Soap and Syndet Cost versus Water Hardness

These data show the cost per pound of soap and syndets in 1930, 1947, and 1955 related to hardness of the water. The data for 1947 are an estimate.

1. *Cost of operation.* For some treatment plants the cost of operation is one thing but the charge to the domestic consumer is another. The author knows of one municipal water plant with a 10–15-mgd capacity which specified a softening increment of 21 cents per 1,000 gal for small domestic consumers. For the average domestic consumer the increment was 14 cents per 1,000 gal and for commercial and industrial consumers, 2 cents. It is evident in this case that the domestic consumer, upon whom detergent savings data are based, would be paying much more than the operation cost per 1,000 gal.

2. *Cost and use data.* The writer has certain reservations about accepting the Purdue University data (*1*) cited by the author. The "average" individuals and families upon which this study relies would not necessarily be statistically representative of actual individuals or families. By the same reasoning, one 5-member family, the individual members of which are not described, does not necessarily indicate the per capita average for the country. (It may, however, be representative of similar 5-member families.)

The Purdue University study probably is the best that could be made with the funds provided. It should, therefore, be of interest to compare these data with those of a retail sales study made in 1930 (*2*).

Figure 2 shows the consumption of soaps in 1930 and consumption of syndets and soaps in 1955. The low con-

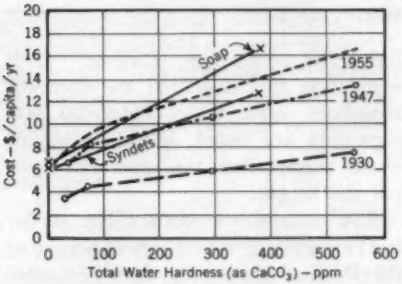

Fig. 4. Cost of Cleansing Agents versus Water Hardness

These data are the combined data of Fig. 2 and 3. Data for 1947 were secured by multiplying the 1930 data by 1.8.

sumption for zero hardness is not surprising. It is reasonable to expect a more rapid increase in consumption in the lower ranges of hardness (zero–40 ppm).

Figure 3 compares the cost of soaps in 1930 and 1947 and syndets and soaps in 1955. An examination of the Purdue University study discloses that the Warren family used the same priced soaps, syndets, and shampoos with soft water as with hard. The bulk of the savings recorded during the soft-water periods occurred with lower-priced syndets and soaps. As a result, the average cost per pound of the *total* annual consumption was greater with soft water than with hard. Another relevant factor may be that advertising pressures had greater influence on the consumer in 1955 than in 1930 and would have influenced buying habits even if water hardness were zero.

Figure 4 combines the data of Fig. 2 and 3 on the basis of cost per capita per year. The estimates for the year 1947, which preceded present significant use of syndets, increased use of automatic washers, and other factors, were secured by multiplying the 1930 data by 1.8.

3. *Insufficient data.* A straight line is the shortest distance between two points, but two points of unknown confidence limits do not require a straight-line relationship. The straight line may express the correct relationship, but this would appear to be a coincidence in view of the 1930 data on annual pounds per capita use and costs per pound of detergent. Detergent-use economics may possibly be better represented by a curve similar to the 1955 cost line in Fig. 4. The correct relationship has not yet been conclusively established.

The available data on water softening and detergent economy demonstrate that hard water requires the domestic use of more syndets and soaps than does soft water. There is a positive need, however, for better data than are now available.

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Use of the Control Chart in Checking Anion-Cation Balances in Water

Arnold E. Greenberg and Remo Navone

A contribution to the Journal by Arnold E. Greenberg, Chief, Sanitation Lab., Berkeley, Calif., and Remo Navone, Chief, Branch Public Health Lab., Los Angeles, Calif., both with the Div. of Labs., State Dept. of Public Health, Calif.

A VARIETY of methods are used for checking the correctness of mineral analyses of water. *Standard Methods* (*1*) suggests three such methods: [1] the anion-cation balance, [2] electrical conductance, and [3] the use of ion-exchange resins. Although the last two may be simpler than the first, laboratories making complete mineral analyses can profitably use the anion-cation balance.

The sum of the cations, in milliequivalents per liter (all equations in this article are in terms of me/l), must theoretically equal the sum of the anions, expressed in the same units. This theoretical balance seldom is observed in routine laboratory operations. The question then arises of how large a difference is acceptable. Some laboratories use an empiric factor: the difference between the sums of the anions and cations should not exceed a given percentage of the sum of either the anions or cations, or the sum of all ions. Five per cent of the sum of the anions is frequently used. *Standard Methods* (*1*) suggests that in routine work "the maximum difference between the sum of the anions and the sum of the cations should not exceed 0.3 me/l when the sum of the anions is as low as 6 me/l, nor should it exceed 1 me/l when the sum of anions is 60 me/l." This is equivalent to 5 per cent at the lower level, but only about 1.7 per cent at the higher ionic concentration.

A review of the literature has shown no data to support any uniform level of acceptable deviation. For this reason an evaluation of the analytical results obtained in two laboratories over a period of almost 3 years was undertaken. It is the object of this article to present these data, to analyze them, and to suggest how both the data and the method of analysis may be used in other laboratories.

Procedure and Results

Two laboratories of the California State Department of Public Health provided the data which are evaluated in this article. These laboratories used analytical methods which were, with only slight modifications, essentially those given in *Standard Methods* (*1*). The data were collected over a period of 3 years, during which about fifteen different chemists made the analyses. In routine practice the sum of the anions includes only alkalinity and the chloride, sulfate, nitrate, and fluoride ions. Normally, phosphate is not determined. The sum of the cations includes calcium, magnesium, sodium,

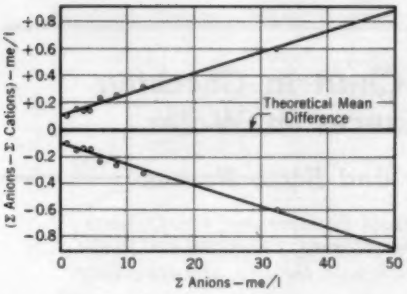

Fig. 1. Control Chart for Anion-Cation Balances

For each group of samples the midpoint of the range is plotted against ± 1 standard deviation for that range. The lines of best fit were found by the method of least squares. The equation of these lines is: Σ anions − Σ cations = ± (0.1065 + 0.0155 Σ anions). This graph has no provision for a time scale.

and potassium. Iron and manganese are also determined, but are usually negligible and are not included in the sum of the cations.

A total of 971 separate samples was included in this study. The sum of the anions ranged from 0.16 to 49.94 me/l. After arranging the sums of the anions in an increasing series, they were divided into eight groups, each containing an approximately equal number of samples. In addition to the sum of the anions, the tabulation included the differences between the sum of the anions and the sum of the cations.

The normalcy of the distribution of differences was checked by the graphical methods described by Velz (*2*). All groups had a normal distribution so that computation of mean and standard deviation of the differences could be made and safely used. These data are shown in Table 1; Fig. 1 shows these results graphically.

Control Charts

In laboratory control, simple, easily applied control systems are desirable. The control chart seems to represent the desired goal. Control charts have been widely used in industry (*3,4*) and, during the past 10 years, have found increasing application in the field of chemistry (*5,6*). As far as the authors know, however, they have not been used in water laboratories for checking the accuracy of analyses.

The control chart is designed to detect the presence of assignable causes of variation; that is, causes of variation which can be found and eliminated. In effect, the chart takes groups of individuals, so-called rational subgroups (*4*), measures the population variation, and then checks the different subgroups on the assumption that there will be no significant difference between the subgroup averages. To construct a chart, a series of subgroups or samples of size n is analyzed, the mean ($\bar{x}$) and standard deviation (s) of each group is determined, the average mean ($\bar{\bar{x}}$) and average standard deviation ($\bar{s}$) are determined, and control limits

TABLE 1

Calculation of Means and Standard Deviations in Anion-Cation Balances

No. of Samples in Range	Range	Midpoint of Range	Mean Δ, Σ anions − Σ cations	Standard Deviation
	me/l			
123	0.00–2.00	1.00	+0.0134	0.1072
122	2.01–3.00	2.50	+0.0044	0.1512
128	3.01–4.00	3.50	−0.0251	0.1396
110	4.01–5.00	4.50	−0.0170	0.1400
126	5.01–7.00	6.00	−0.0583	0.2334
136	7.01–10.00	8.50	−0.0423	0.2591
116	10.01–15.00	12.50	−0.0587	0.3174
110	15.01–50.00	32.50	+0.1536	0.5976

are selected. If $\bar{\bar{x}}$ is the mean of k samples of size n, and $\bar{s}$ is the average standard deviation, then the most frequently used limits are: $\bar{\bar{x}} + 3\bar{s}n^{-\frac{1}{2}}$* and $\bar{\bar{x}} - 3\bar{s}n^{-\frac{1}{2}}$ on the vertical scale. The horizontal scale is usually used for a time sequence or for successive samples. Thus, the process is sampled periodically and sample means are plotted as points on the chart. If a point falls outside the selected control limits, the process being studied is halted and examined for sources of trouble, or assignable causes. After these are located and corrected, the operation is resumed.

Using a slightly different notation system, Brownlee (*7*) described the use of inner and outer limits: inner limits, $\bar{x} \pm 1.96\ sn^{-\frac{1}{2}}$, outer limits, $\bar{x} \pm 3.09\ sn^{-\frac{1}{2}}$. The inner limits will include 95 per cent of all means, or in 40 values, one will be above $\bar{x} + 1.96\ sn^{-\frac{1}{2}}$ and one below $\bar{x} - 1.96\ sn^{-\frac{1}{2}}$. Similarly, the outer limits will include 99.8 per cent of all means, or in 1,000 values, one will be above $\bar{x} + 3.09\ sn^{-\frac{1}{2}}$, and one below $\bar{x} - 3.09\ sn^{-\frac{1}{2}}$. The inner limits may then be used to define the caution area and the outer limits the danger area.

Use of Control Chart

The control chart system can be applied to anion-cation balances. It must be noted, however, that it is not possible to plot directly limits which are parallel to a mean line. The reasons for this are: [1] the standard deviation of the difference between the sum of the anions and the sum of the cations increases with increasing ionic concentration, and [2] instead of having rational subgroups with a large n, the chemist is concerned with rational subgroups containing single analyses where n equals 1. A graph, such as Fig. 1, may be used to eliminate the first difficulty. It is true that there is no provision for the usual time scale on the x axis of Fig. 1, but, inasmuch as the sum of the anions varies widely and plotting points will seldom be superimposed, it may be possible to dispense with the time scale. The plotted points may be coded by color or number to show variations as a function of time. It is also possible to transform the ordinate and have a conventional type of chart. Thus, by plotting as follows:

$$\frac{\Sigma \text{ anions} - \Sigma \text{ cations}}{0.1065 + 0.0155\ \Sigma \text{ anions}}$$

the line is normalized and the limits become ± 1. This is shown in Fig. 2. In practice the charts shown in Fig. 1 and 2 may be used together.

Not only can these limits be used in overall laboratory control, but they may be used in the controls of individual chemists, if each chemist makes a complete analysis. As an example, the results obtained by two chemists have been plotted (Fig. 2). Chemist 1 had 45 per cent of the analyses out of control, that is, outside the limits of $\pm 1s$, whereas Chemist 2 had only 16 per cent of his results outside the limits. gure 2Fi shows that Chemist 1 obtained comparatively poor results in his chart, but Chemist 2 did better. The theoretical outage is 32 per cent. It may also be noted that Chemist 2 obtained 30 negative differences and only 12 positive ones. Although no explanation for this is available now, it is clear that an explanation must

* The expression $3\bar{s}n^{-\frac{1}{2}}$ is equivalent to:

$$\frac{3\bar{s}}{\sqrt{n}}$$

exist in terms of a systematic error, analytical bias, or other analytical difficulty.

Despite the practices cited in this article, the selection of control limits always requires an arbitrary decision. If limits of 2*s* or 3*s* are selected as acceptable outer limits, the chemist must expect more results to be accepted which show relatively large differences between the anions and cations. If a limit of $\pm 1s$ or less is selected, fewer poor analyses will be accepted, but more analyses will have to be repeated. Accepting a limit of $\pm 1s$ will result, on the average, in rejecting about 32 per cent of all analyses. Thus, a balance must be made between the number of rejected analyses and the quality of results produced by the laboratory. If control by means of anion-cation balances is the sole control on the correctness of mineral analysis of water, as it usually is, it does not appear unreasonable to set high standards. *Standard Methods* (*1*) requires such standards, and many professional water chemists do likewise. Actually, the limits given by the equation: Σ anions $-$ Σ cations $= \pm$ (0.1065 + 0.0155 Σ anions), correspond quite closely to those values suggested by *Standard Methods*, thus providing support to those recommendations. It is suggested, therefore, that the acceptable limits be taken as ± 1 standard deviation.

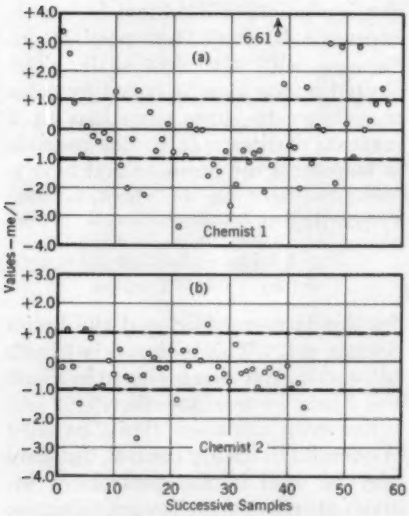

Fig. 2. Control Chart With Transformed Limits

The vertical scale is plotted:

$$\frac{\Sigma \text{ anions} - \Sigma \text{ cations}}{0.1065 + 0.0155\ \Sigma \text{ anions}}$$

The results obtained by Chemist 2 are superior to those obtained by Chemist 1.

Application of Data

It is felt that the data presented in this article, as two laboratories and some fifteen chemists participated in their collection over a period of 3 years, may be applicable as a first approximation in any laboratory. Until such time as a laboratory director can evaluate for himself the variations in his results, he may use the standard deviations determined by this study. Therefore, as a first approximation in analytical control, the limits shown in Fig. 1 and 2 and given by the expressions:

$$\Sigma \text{ anions} - \Sigma \text{ cations} = \pm\ (0.1065 + 0.0155\ \Sigma \text{ anions}),$$

and

$$\frac{\Sigma \text{ anions} - \Sigma \text{ cations}}{0.1065 + 0.0155\ \Sigma \text{ anions}}$$

may be used.

In quality control work initial limits are usually determined either on the basis of a relatively small

number of special samples or, as was done in this work, on the basis of a large number of samples collected over a long period of time. The latter is essentially an historical approach. It is suggested that these initial limits be used, but that after more data are collected the statistical analysis be repeated and new limits constructed. This could and should be done. In recalculating the standard deviations, however, all values, including those which were rejected, should be used. In view of personnel turnover, changes in standard methods of analysis, and other factors, it seems best to reevaluate the limits as more information is obtained.

TABLE 2

Significance of t in Anion-Cation Balances

Range—*me/l*	*t*	Significance at 95% Confidence Limits
0.00–2.00	1.39	Not significant
2.01–3.00	0.32	Not significant
3.01–4.00	2.03	Significant
4.01–5.00	1.27	Not significant
5.01–7.00	2.80	Significant
7.01–10.00	1.90	Not significant
10.01–15.00	1.99	Significant
15.01–50.00	2.70	Significant

Table 1 shows that the mean difference between the sum of the anions and cations was never zero. With the exception of the 15.01–50.00 range samples, it appears that the difference becomes increasingly negative as the sum of the anions increases. To determine whether these differences from zero were significant, the *t* test was used (*7*):

$$t = \frac{\bar{x} - E}{sn^{-\frac{1}{2}}}$$

The expected value (E) was in all instances zero, and the mean of anions minus cations ($\bar{x}$), the standard deviation (s), and the number of samples in the range (n) were the same as shown in Table 1. The results of this test are given in Table 2.

By entering a table of *t*, the value at which *t* is significant at the 95 per cent confidence level is found; in this case it is 1.96. It cannot be concluded whether or not the mean differences between the anions and cations were significantly different from zero. This may mean that those values not in agreement with the theoretical expectation are different from those reported here. It is felt, however, that these differences would be slight; thus, the use of such limits is not invalidated. The chemist may be inclined to plot $\pm 1s$ around the observed differences between the sums of the anions and cations rather than around zero, the expected difference. This would complicate use of the control chart, but it can be done. The equation for the upper limit would then be:

$$\Sigma \text{ anions} - \Sigma \text{ cations} = 0.0575 + 0.0205 \Sigma \text{ anions},$$

and for the lower limit:

$$\Sigma \text{ anions} - \Sigma \text{ cations} = -0.1541 - 0.0105 \Sigma \text{ anions}.$$

It is unlikely that the use of the suggested limits:

$$\Sigma \text{ anions} - \Sigma \text{ cations} = \pm (0.1065 + 0.0155 \Sigma \text{ anions}),$$

would introduce any serious errors. The reasons for this failure to agree are being further investigated.

Summary

A statistical evaluation has been made of the results of 971 mineral analyses performed in two labora-

tories over a 3-year period. Using the difference between the sum of the anions and the sum of the cations, both in milliequivalents per liter as a function of the sum of the anions it is possible to set limits of acceptable variation from the theoretical difference of zero. By means of a control chart a rapid inspection of results can be made.

It is suggested that the limit of ± 1 standard deviation be used. In the absence of data for a given laboratory, it is further suggested that the limits calculated in this article:

$$\Sigma \text{ anions} - \Sigma \text{ cations} = \pm (0.1065 + 0.0155 \Sigma \text{ anions}),$$

can be used as a first approximation.

Acknowledgments

The statistical advice of Prof. William Gaffey of the University of California and Mrs. Laura Gong of the California State Department of Public Health is gratefully acknowledged. Miss Priscilla Ferguson of the Public Health Library of the University of California assisted in the literature review.

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Experimental Performance of 'Miracle' Water Conditioners

—*Rolf Eliassen, Rolf T. Skrinde, and William B. Davis*—

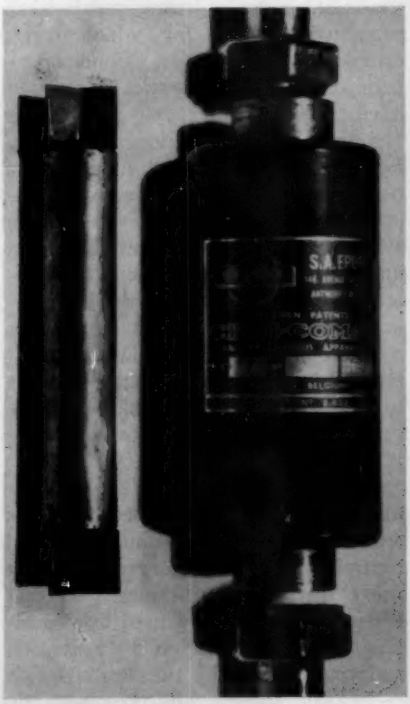
A paper presented on Apr. 24, 1958, at the Annual Conference, Dallas, Tex., by Rolf Eliassen, Prof. of San. Eng., Rolf T. Skrinde, Research Asst., and William B. Davis, Research Asst., all of Massachusetts Inst. of Technology, Cambridge, Mass.

WATER, the universal solvent, contains many impurities caused by the solution of compounds with which it comes into contact. Even rain as it falls to the earth is not pure water, because it picks up dusts and dissolved gases from the atmosphere. Ground waters leach other products from the soil. In some cases the impurities in water lead to increased corrosiveness, while in others the dissolved solids tend to form scale on surfaces such as in pipelines and boiler tubes. Treatment of water to prevent scale and corrosion is therefore necessary in most industries and municipalities. Unfortunately, there is no single treatment process which will be a utopian answer for all purposes. Certain chemical additives to control corrosion may lead to increased scaling tendencies. On the other hand, demineralization to prevent scale buildup may lead to increased water corrosiveness. It may readily be seen that there could be a tremendous potential market for a simple water-conditioning device which would prevent scale and corrosion in small individual installations such as steam boilers, air-conditioning units, and household water lines.

Such a simple water-conditioning device, based on sound scientific principles, has never been developed and proved by precise measurements of its physical and chemical effects on the mineral constituents of water. In an attempt to produce a simple water-conditioning device, many people have promoted gadgets for which many claims have been made. Some members of the water works profession have referred to these gadgets as "miracle water conditioners." They have been sold in great numbers, as pointed out in the "Perspectives" column of *Product Engineering* (*1*) in 1953: "Despite the frequent charges of quackery raised against them, the anti-scaling water conditioners are big business. One of the current best sellers costs from 50 to 3,000 dollars, depending on size. The manufacturer claims to have sold 100,000. Observers think he's being modest; the correct figure is probably closer to 150,000."

Welder and Partridge (*2*) have defined these gadgets as "special devices requiring substantially no technical control which are alleged to treat water by nonchemical means so that the familiar troubles caused by deposition of scale or sludge, by corrosion and cracking, or by the accumulation of organic slimes, will plague us no more." The dictionary defines "mira-

(a)



(b)

(c)

Fig. 1. Water "Conditioner" Units

(a) Evis; (b) Cepi; (c) Packard.

cle" as: "an event or effect in the physical world . . . deviating from the known laws of nature."

Over the past century a substantial number of these miracle gadgets have been promoted vigorously for a while and then have fallen into oblivion, as shown by Henricks (*3*). An earlier article by Eliassen and Uhlig (*4*) discussed several of the gadgets which were available in 1952, described the promotional methods used, and discussed the electronic, nuclear, or other principles involved. In almost all cases no technical data are presented by the manufacturers to substantiate the claims discussed in that paper.

Description of Conditioners Studied

Despite past water "conditioner" reports, requests for further information on and evaluation of gadgets not mentioned in the above papers have come to the attention of the authors. These requests have concerned mostly the three units which are described below —the Evis Water Conditioner, manufactured by the Evis Manufacturing Company of San Francisco, Calif.; the Packard Water Conditioner, made by Packard Water Conditioner, Inc., Jacksonville, Fla.; and the Cepi-Comav, manufactured in Belgium and distributed by Cepi-American, Inc., River Forest, Ill. The authors believe that all of these come under the definition previously quoted from Welder and Partridge (*2*) in that they are "special devices requiring substantially no technical control which are alleged to treat water by nonchemical means, etc." The means of "conditioning" employed in each of the three units are different and are worth comparing in a side-by-side presentation. Exterior views of the three units are shown in Fig. 1 and interior views in Fig. 2.

The Evis Water Conditioner (Fig. 1a and 2a) is a pipe fitting shaped like an oversized pipe coupling. It contains an interior cross post or protuberance around which the water flows. The manufacturer states (*5*) that, by the use of a specially processed metal, it "performs the function of a Catalytic

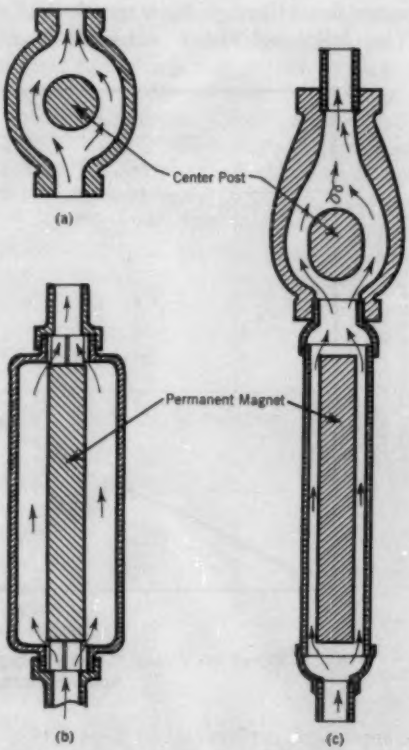


Fig. 2. Schematic Diagram of Water "Conditioner" Units

(a) Evis; (b) Cepi; (c) Packard.

'Promoter' or 'Activator' by so altering the electronic structure of water molecules that the adsorption properties of its solutes and contaminants are thereby altered." One bulletin (*6*) states that Evis "removes old pipe

scale—prevents new scale from forming," and others discuss the use of Evis for corrosion control. A report of a laboratory study of this unit by Eliassen and Skrinde (*7*) was published in 1957.

The Cepi unit (Fig. 1b and 2b) consists of one or more permanent magnets placed in a housing so that the water flows through the magnetic field. The following rather extensive and complicated explanation of Cepi action has been prepared by its distributor (*8*):

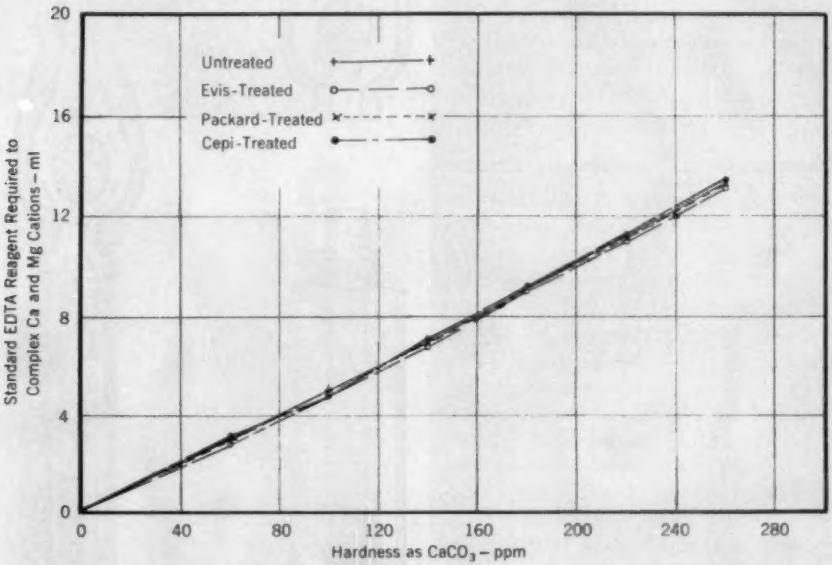


Fig. 3. Effect of Water "Conditioning" Devices on Complexing Properties of Scale-Forming Components

The principle and theory of the magnetic process consists of conducting the liquid through concentrated magnetic fields of measured intensity, relative to the concentration of ions and their dipole moment. Liquid passing through these magnetic fields, results in a change so that at the moment of crystallization of the salts, the polarization between the zones of strong ionization will be diminished and the cohesive forces will be neutralized. This action results in a cleavage of the crystal into very thin layers and an orientation of the ions as per one magnetic axis. The resulting action upon crystals of the scale forming salts is that instead of forming scale, the crystals precipitate as a fine amorphous powder that is non-adherant to metal and other surfaces, nor to each other, and can be removed by draining, blow-down or flushing. The same phenomena takes place when old scale is in contact with the treated fluid as it becomes soft, dehydrated, and finally falls loose as a powder or soft flakes as the treated water has the ability to transfer its' treatment to the water molecules in the scale and effecting the scale crystals. Corrosion is neutralized partially or entirely, depending upon the composition of the liquid, by diminishing the electrostatic

tension forces on the surfaces of the zones of strong ionization.

The Packard Water Conditioner, shown in Fig. 1c and 2c, appears to combine the physical features of the Evis and Cepi units, in that the Packard employs both a center post around which the water flows, and a permanent magnet in its long, double-chamber housing. The components of this device are described by its manufacturers as follows (*9*):

> The dispersing cell contains the "Perma-Core," a kinetic energy generator made of a patented metal of extreme density whose energy shows itself in alternating fields of unusual magnetic intensity. The "Perma-Core" is a permanent well of static energy. This energy force modifies the structure of the molecules of minerals and salts in the water. . . . The homogenizing or mixing chamber is an alloy casting containing a core against which the flow of water is directed in such a way that the water is tumbled upon itself to produce a homogeneous energy distribution within the molecules of the solution.

The Packard manufacturers claim (*9*) that their conditioner "is the first important application of nuclear physics principles to the effective treatment of water to combat scale and corrosion. It prevents scale and corrosion by imparting added energy to the atoms of the water solution. The added energy . . . establishes a uniform electrolytic potential within the system and stops corrosion."

Scope of Studies

Claims such as these have no significance to the water works profession unless they can be substantiated by experimental evidence obtained in a manner similar to that used in evaluating other water treatment processes.

An attempt has been made to study the performance of these units in the laboratory and in the field, and to measure the performance in terms of the latest scientific methods applicable to water works practice. The measurements and tests were directed toward the effects of the "conditioners" on water, in the light of some of the claims made by one or more of the manufacturers. The laboratory tests sought to evaluate claims such as those regarding effects on ionic structure of water constituents, effects on scale formation (using stable and radioactive calcium), effects of strong magnetic fields on scale formation, and effects of the "conditioned" water on scale dissolution and on the corrosion of iron. Field tests were directed toward evaluating the effects of water "conditioned" by these devices on the corrosion of steel pipe.

Effect on Ionic Structure

As mentioned previously, claims have been made including such phrases as "altering the electronic structure of water molecules" (*5*), "diminishing the electrostatic tension forces on the surfaces of the zones of strong ionization" (*8*), and "modifies the structure of the molecules of minerals and salts in the water" (*9*). Because the metallic ions of calcium and magnesium are so important in the formation of scale, the authors contend that any alterations in ionic or molecular structure should have a measurable effect on the complexing action on calcium and magnesium in "conditioned" water. Tests which involve complexing and its precise measurement have been perfected in the past decade by water chemists through the use of ethylenediaminetetraacetic acid (EDTA).

Laboratory studies were made on the three water "conditioners" with respect to any changes which could be observed in any complexing effects, as measured by the standard EDTA test (*10*). Cambridge tap water, with various degrees of hardness added, was passed through each of the three units. Tests were made on the complexing of the calcium and magnesium of hard waters, was not affected by these "conditioners" as shown by the results of these tests.

Effect on Scale Formation

Water "conditioners" of the type discussed above have many claims made for their effectiveness in the prevention of scale and removal of existing scale. Field tests to evaluate the

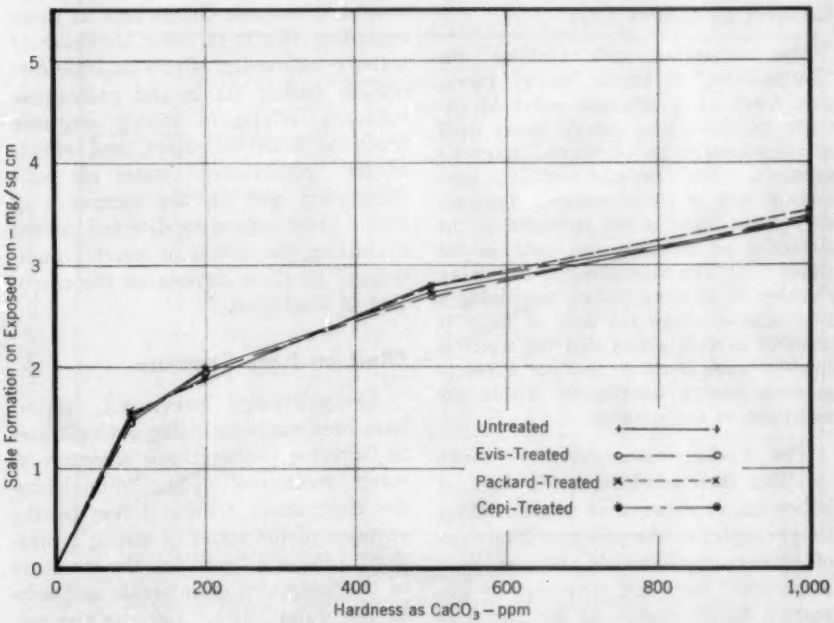


Fig. 4. Effect of Water "Conditioning" Devices on Scale Formation

in the three "conditioned" waters and also in untreated water as a control. The results are presented in Fig. 3, which indicates that no significant difference was observed in the complexing properties of the scale-forming components of the hard waters tested. The soap-consuming property, one of the most significant chemical attributes

effect of these devices on scale formation are difficult to perform because long periods of time are required, municipal treatment procedures may change during the course of the test, and it is hard to maintain identical conditions in boilers or other structures using treated versus untreated waters. A laboratory study is much

more accurate in maintaining controlled conditions and making precise measurements.

Scale formation through heat was investigated with water of various compositions which had been "conditioned" by the three devices. Strips of steel were suspended in flasks containing the "conditioned" waters and untreated controls, and heated on a water bath to cause evaporation with the production of steam. At the completion of the evaporation process the strips were weighed to determine the amount of scale formed. Figure 4 shows that the scale formation was the same in quantity in both the "conditioned" and the untreated waters. It was also noted that the steel specimens became quite rusty during the evaporation period. The samples placed in the "conditioned" waters corroded to the same extent as those in the control flasks. The results of these tests indicated that scale and corrosion, at least during the initial stages on bare metal, were not affected by any of the three "conditioning" devices.

Radioactive-Calcium Studies on Scale Formation

An extremely effective method of measuring the deposition of calcium precipitates, and a new scientific technique in water analysis, is the use of radioactive tracers. Radioactive calcium 45 is a beta emitter with a half-life of 163 days. With an energy of 0.25 Mev, it is well suited for counting with a Geiger-Muller radioactivity counter. A known quantity of calcium 45 is added to the sample. The amount of radioactive calcium deposited on steel surfaces during evaporation processes is then an indication of the amount of calcium precipitating out as scale.

Samples of water with a high hardness content were treated with the three devices and placed on a steam bath for evaporation. The steel specimens were cut from 0.9-in. diameter bars and were machined to fit into nickel-plated counting planchets. As the water evaporated away with time, the scale deposition increased as shown in Fig. 5. The deposition of radioactive calcium 45 on steel was not affected by "conditioning." The results of this test, using the latest radiochemical techniques, supplement the previous scale formation study and serve to verify the results in Fig. 4.

Effect of Strong Magnetic Fields on Scale Formation

Changes in the scale-forming properties of water as a result of subjecting it to magnetic fields have been claimed by two of the manufacturers of water "conditioning" devices. Although the magnets are strong for their size, the use of any tremendously large magnets of great magnetic field intensities by the manufacturers is evidently not commercially feasible, especially for the ordinary small installations.

Claims are made that the strong permanent magnets impart energy to water passing through the magnetic field. The Packard statement reads: "prevents scale and corrosion by imparting added energy to the atoms of the water solution." This claim is made in the face of the additional claim of using a permanent magnet—one which will not lose energy as time goes on. This is contrary to the most fundamental laws of nature such as the well established Second Law of Thermodynamics, which maintains that as energy is taken up by one body it must be given up in like amount by

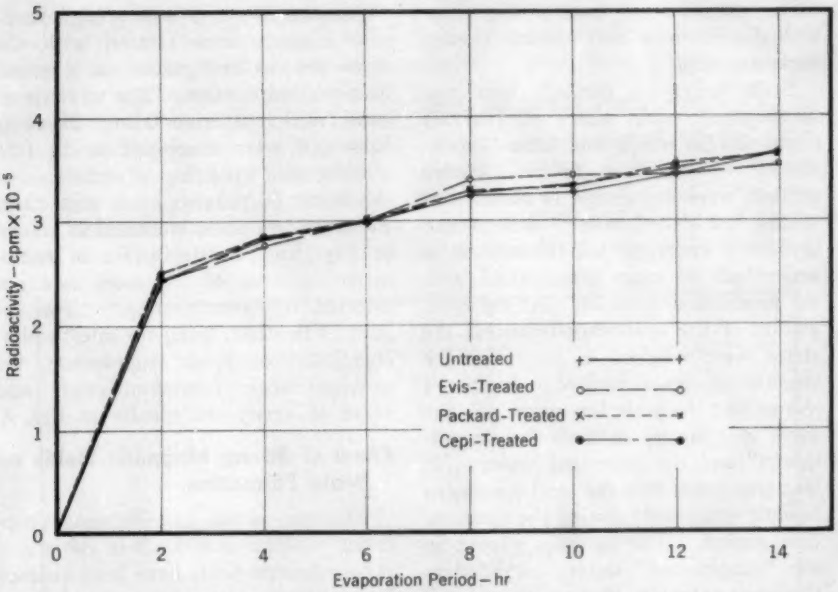


Fig. 5. Effect of Water "Conditioning" Devices on Radioactive Scale Formation

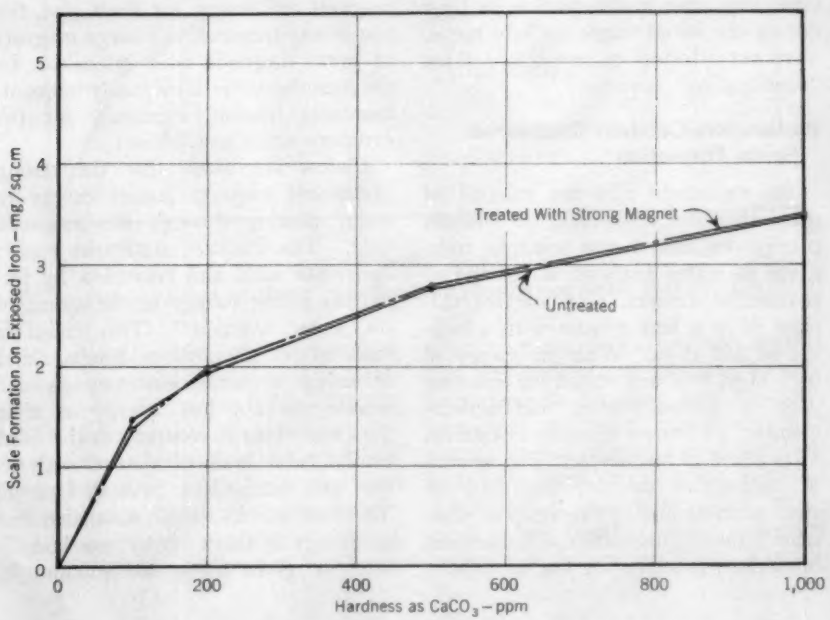


Fig. 6. Effect of Strong Magnetic Fields on Scale Formation

another body, whether the energy is electrical, mechanical, or chemical—in other words, energy must come from some source which must be expended, and not from a permanent nonexpendable source. For instance, at Massachusetts Institute of Technology, an extremely high continuous magnetic field of 100,000 gauss has been created by Francis Bitter, dean of the School of Science. "To accomplish this he must keep filling his coil with magnetic field as fast as it leaks out—a procedure involving a million-watt generator for power and part of the Charles River for coolant" (*11*).

Physicists have shown (*11*) that even this huge field is not enough to influence the particles within atoms. Magnetic fields of the order of magnitude of 1,000,000 gauss are needed "to dominate the motions of charged particles within atoms" (*11*). This field strength is equivalent to an energy density of about 5,000 joules/ml. By contrast, an energy density of only 0.5 joule/ml was caused by the magnets used in the magnetic water "conditioners" tested. There is a 10,000-fold difference in energy densities!

Even so, it was deemed advisable to run experiments with a very strong magnetic field to obtain an indication of the effect on scale formation of a very strong magnetic field on water at a low flow rate. Samples of water of varying hardness were subjected to approximately twenty times the degree of magnetic treatment imparted by some of the devices. The rate of flow was 1 gpm. Such treatment should be much stronger than that accomplished by magnetic treatment through ordinary water "conditioning" devices, and should presumably have a greater effect on scale formation. The test method was the same as previously described with regard to scale formation on steel strips. Figure 6 shows that, even with such a strong magnetic treatment, the weight of scale deposited was not significantly different from that of the untreated waters.

Effect on Scale Dissolution

The water "conditioning" devices tested have been recommended by their proponents for use in cleaning scale from old water lines. Some data have been presented by the manufacturers in support of their claims in this respect, but the authors have seen no data from manufacturers based on studies in which controls of untreated waters were tested under identical conditions and rigorous comparisons made.

Two types of laboratory studies were made. In the first tests, scale was placed in separate vessels containing "conditioned" waters and untreated waters. The amount of scale passing into solution was measured by the EDTA hardness test. The results of this investigation are shown in Fig. 7. The curves are virtually superimposed and indicate that water "conditioned" by the devices in the laboratory had no measurable effect on the rate of scale dissolution. It would thus appear that in these tests the water "conditioning" devices did not change the characteristics of the water so that it would penetrate the scale and dissolve it more readily.

In another investigation of scale solubility produced by using "conditioned" versus untreated waters, scale containing radioactive calcium 45, which was coated on metal specimens, was allowed to dissolve in distilled water. At regular intervals samples of the water were evaporated in planchets and measured for calcium 45 concentration in a Geiger-Muller counter. The amount of calcium 45 passing into

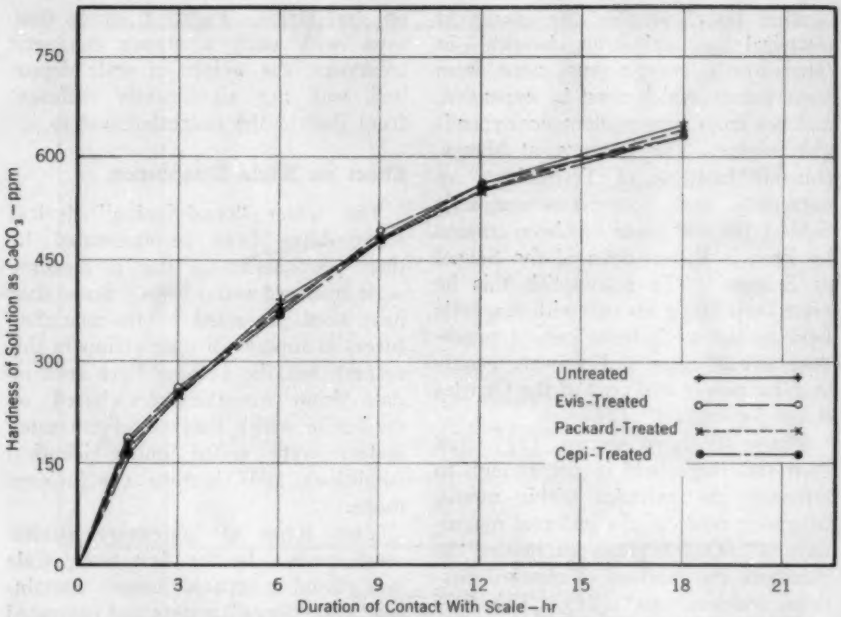


Fig. 7. Effect of Water "Conditioning" Devices on Removal of Scale

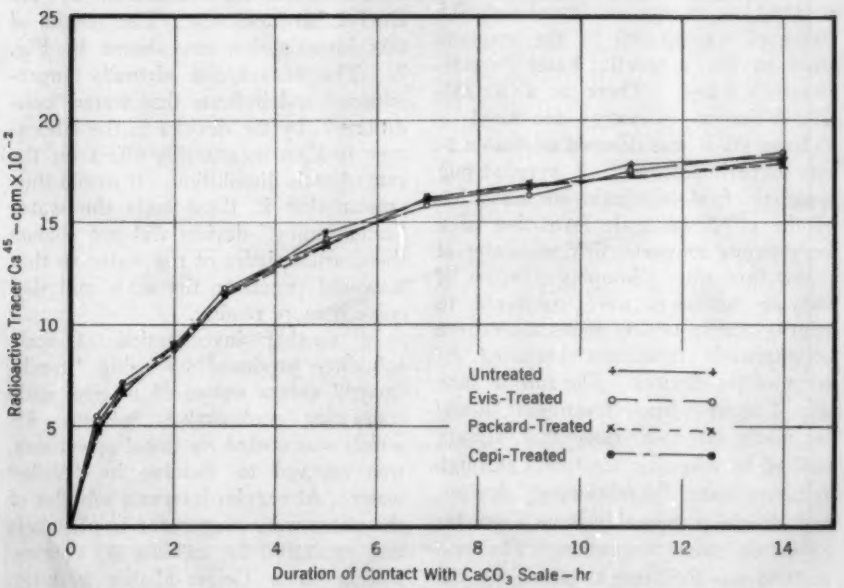


Fig. 8. Effect of Water "Conditioning" Devices on Dissolution of Calcium Carbonate

solution was used as an indication of the rate of scale dissolution. The results of these tests are plotted in Fig. 8. It is evident that the three water "conditioning" devices did not affect the solution of scale as measured by the radioactive-tracer method.

Effect on Corrosion

The control of corrosion in pipelines and other surfaces in contact with water is one of the claims made for these water "conditioners." If the magnetic, catalytic, or other effects produced by the "conditioners" could prevent corrosion, the savings in the United States alone would amount to billions of dollars per year. The theory as to how the "conditioners" might control corrosion is not clear in statements made by the manufacturers. Many years of water works practice has led to the commonly used lime or soda ash addition to neutralize free carbon dioxide and provide an eggshell calcium carbonate coating in water lines, or to the addition of metaphosphates or silicates. These methods have been described in the JOURNAL on many occasions (*12*).

For field testing, the three water "conditioning" devices were placed in water lines at the Cambridge Filtration Plant. Cambridge tap water was piped into four identical pipelines, one of which was a control line. Specimens of black-iron pipe were especially prepared in the laboratory to make them uniform for corrosion studies. They were then weighed and inserted into the four pipelines. At periodic intervals specimens were removed from each line and analyzed for rust or scale formation and weight loss upon removal of the deposits. Results of the weight loss determinations are

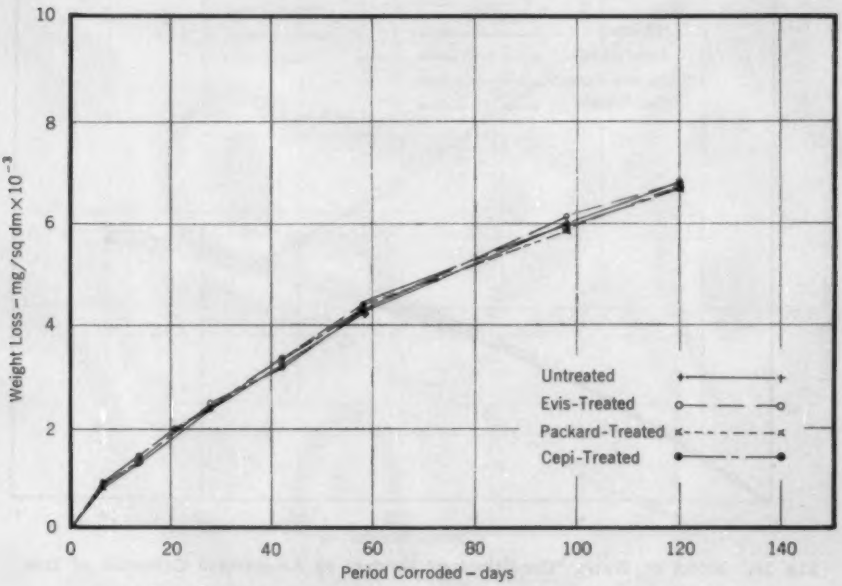


Fig. 9. Effect of Water "Conditioning" Devices on Iron Pipe Corrosion

presented in Fig. 9. It can be seen from the curves that there was no difference in corrosion as determined from weight loss studies over a period of 4 months. The corrosion products of light-brown rust were the same in quantity and physical appearance in all of the test lines. The rust appeared as small pinpoints at first, and then grew until the whole surface of the pipes became covered with a thin layer.

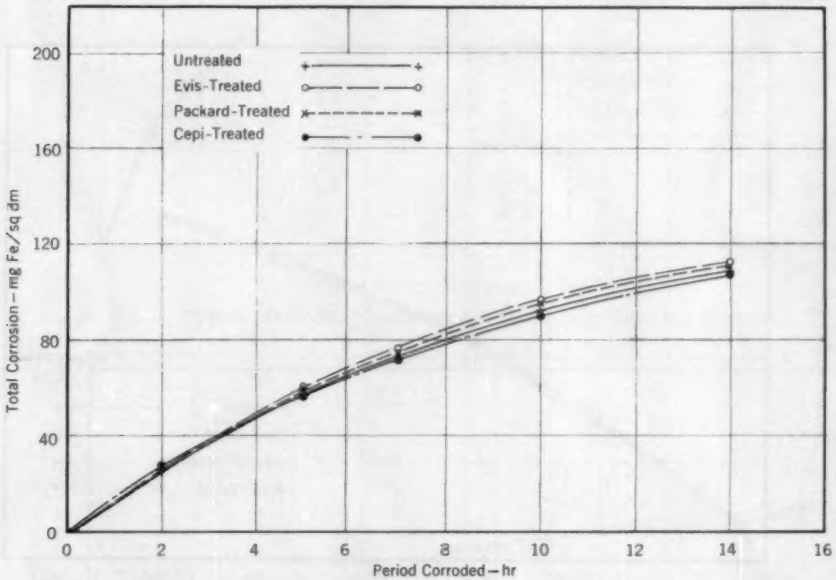


Fig. 10. Effect of Water "Conditioning" Devices on Accelerated Corrosion of Iron

Even the water "conditioning" units themselves were not immune to corrosion and scaling. At the end of the test a heavy rust deposit was found in each water conditioner.

Accelerated Laboratory Corrosion Tests

Further corrosion studies were made in the laboratory by measuring oxygen utilization caused by the rusting of iron to its oxide form during the corrosion process. The direct method of Warburg was used, in accordance with the standard analytical procedure described in detail by Umbreit and colleagues (*13*). The Warburg method of measuring oxygen utilization is based on the change in pressure of a constant-volume system resulting from the uptake of oxygen from that system. Chemical methods of oxygen utilization have often been applied previously for measuring the corrosion of iron, but the use of the Warburg respirometer for this purpose is a new scientific technique which should find considerable application in the corrosion control field.

The results of corrosion studies using the Warburg respirometer are presented in Fig. 10. In these studies, the water samples were taken from the

pipelines containing the "conditioning" units at the Cambridge Filtration Plant. The iron specimens were equal lengths of iron wire 0.008 in. in diameter and of uniform cross-sectional area. Figure 10 shows that the corrosion of iron in the "conditioned" waters was slightly higher than the control in two cases and slightly lower in one case, but the corrosion rates are not significantly different and are well within the limits of experimental error.

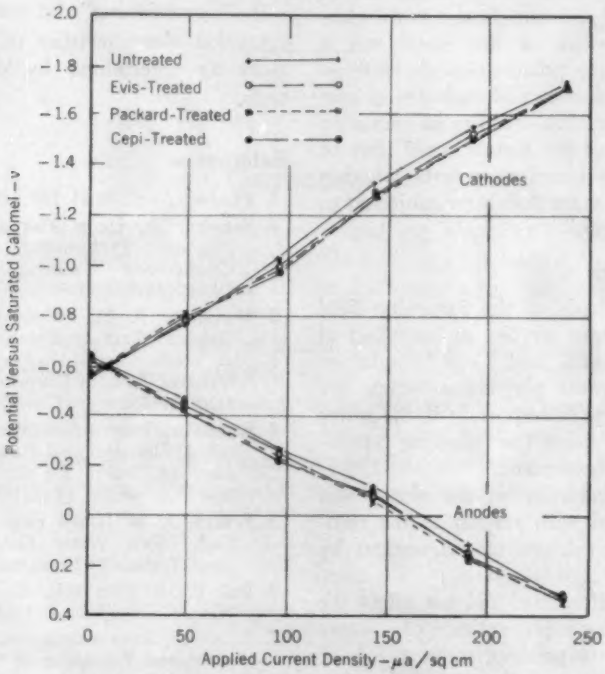


Fig. 11. Effect of Water "Conditioning" Devices on Electrolytic Properties of Iron Surfaces

Polarization Studies

Some manufacturers claim changes in the electrolytic behavior of pipes or other metallic surfaces due to the "conditioned" waters. Statements of changes in electrode potentials, or other metal surface phenomena of an electrolytic nature, relate to corrosion, as corrosion is an electrochemical reaction. The variation in potentials of anodes and cathodes of corroding surfaces with current flow is known as polarization. Polarizing characteristics of separate anodes and cathodes under a given set of conditions may be determined by varying the rate of current flow between the electrodes and measuring the potential of each electrode against that of a standard reference cell. Information obtained in such studies is of great value to corrosion scientists in studying corrosion phenomena (*14*).

The results of polarization studies using water "conditioned" by the three units, with untreated water as a control, are shown in Fig. 11. Steel specimens were placed in corrosion cells. With variations in applied current density obtained by a power supply, electrode potentials were measured against saturated calomel. Treatment with the three "conditioner" units caused neither a significant change in the electrode potential of the metal nor a change in the polarization characteristics of the anodes and cathodes of corrosion cells. No changes in corrosion tendencies of the metals could thus be observed by polarization tests, whether or not the water had been subjected to "conditioning."

Conclusions

On the basis of the foregoing field and laboratory studies on the effect of Evis, Packard, and Cepi "conditioning" on water properties which are considered to be important in the water works profession, the following conclusions may be drawn:

1. The behavior of the water was not changed with respect to the complexing of calcium or magnesium by EDTA.

2. "Conditioning" did not affect the scale-forming properties of water evaporated to produce steam.

3. Precipitation of the scale-forming cation, calcium, upon evaporation of a hard water to steam was not affected by the three "conditioning" devices.

4. Water which was passed through magnetic fields as strong as, and much stronger than, that of the "magnetic" water conditioners was unaffected with respect to scale formation.

5. "Conditioning" did not affect the rate of solution of substances commonly found in hard-water scales.

6. The rate of solution of radioactive calcium 45 from scale was not affected by "conditioning."

7. In field studies, "conditioning" did not affect the rate of corrosion of steel pipes over a 4-month period.

8. Accelerated laboratory corrosion tests indicated no significant effects on corrosion rates by "conditioning."

9. "Conditioning" did not affect the corrosion characteristics of steel surfaces as determined by polarization tests.

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Correction

In the panel discussion, "Experience in Applying Fluorides" (October 1957 JOURNAL), the assertion was made (p. 1269) that, in an unnamed New Mexico city, "Fluoride values ranged from 0.0 to 3.2 ppm, when they should have been 0.8."

The New Mexico Department of Health points out that there are only two cities in the state which fluoridate their water. In neither case did the fluoride concentration in the distribution system water ever exceed 1.0 ppm during the period covered in the panel discussion in the October 1957 issue. This statement is based on records of daily analyses made in accordance with New Mexico Department of Health requirements and corroborated by the department's laboratory.

Problems Caused by Manganese in Water Supplies

Attmore E. Griffin

A paper presented on Apr. 24, 1958, at the Annual Conference, Dallas, Tex., by Attmore E. Griffin, Tech. Consultant, Div. of Tech. Services, Wallace & Tiernan Inc., Newark, N.J.

THIS article is based on data accumulated by AWWA Manganese Task Group 2680P, under the chairmanship of the author.

Whether or not a water supply has a manganese problem depends to a large degree upon the character of the source, the type of treatment, and the usage—industrial or domestic, or a combination of both. It also depends upon the type of industry using the water and the employees operating the utility.

Manganese is a common ingredient in water supplies in all parts of the country. It can be present in both ground and surface supplies. It is usually associated with iron and the iron content is usually greater than the manganese content. This cannot be taken for granted, however; in a number of places the quantity of manganese will be greater.

Basic Problems

Manganese in water creates several problems: it sometimes defies easy detection, strongly resists removal, passes readily through many types of water treatment, precipitates in the distribution system, produces brownish stains that are difficult to remove from white goods, and reduces the carrying capacity of pipelines; organic deposits containing manganese also may peel off the interior of pipes at inconvenient times.

The detection of manganese is hampered by a lack of simple, effective test methods for distinguishing the various degrees of oxidation. This is a problem that, to the author's knowledge, has not been studied sufficiently. It is widely believed that manganese accumulates in the bottom of deep reservoirs during both summer and winter stagnation periods but is evenly distributed throughout the water during overturn periods. It is also believed that during the stagnation periods the suspended and oxidized manganese settles to the bottom and gradually reverts to the manganous state. There are little data as to how fast these reactions proceed, however, or whether all the oxidized manganese that settles out during periods of stagnation redissolves. Data on these subjects, plus a simple, effective testing procedure, would be of great assistance in manganese removal.

Organic complexes of manganese present another area in which investigation is needed. Sand grain growth when a surface water high in organic material is being processed is always a possibility.

Even if satisfactory methods of detection were available, it is possible for

streams contributing to a newly selected dam site and reservoir to show no trace of manganese, but after the reservoir is filled manganese may develop in the water within 1–10 years. There are many instances on record, both in the industrial and domestic fields of water treatment, where this has happened with such severity that quick and costly remedial action was necessary. The sudden appearance of hitherto unsuspected manganese in newly created reservoirs has happened in all areas of the United States.

The amount of manganese which has been detected in reservoirs varies from 0.2 ppm in some areas to as much as 20.0 ppm in some Tennessee Valley Authority lakes. Future trouble with manganese cannot, however, always be accurately predicted from the amount present in water. The effect of manganese will depend partly upon its exact influence on the distribution system and partly on how the water is used. There is, at present, a growing belief among water technicians that, ideally, all manganese should be removed from water before the water is delivered to the customer. In the past, it was considered acceptable for water to contain 0.3 ppm iron and manganese. It has been suggested that a better standard would be no manganese and 0.3 ppm iron.

When dissolved manganese passes into a distribution system, particularly one in which postchlorination is practiced, it is prone to precipitate quickly and near to the plant, and to gradually fan out into the distribution grid. This causes periodic black water and can result in stained laundry; if a cotton bleachery uses water in which this process takes place serious economic losses may result. Sometimes, upon postchlorination, manganese will deposit on the clear-well walls from which it may periodically detach itself and create a nuisance.

Manganese Removal

Iron can be separated from water relatively easily, sometimes by simple aeration followed by filtration. In this process, however, manganese may pass through without reduction. Manganese is easily and completely removed by the excess-lime softening process, but it may pass through an alum coagulation plant, particularly if chlorine use is low or chloramine residuals are maintained. Manganese will pass undiminished through many types of treatment and precipitate later in the distribution system. Organisms of the Crenothrix type can remove manganese from their metabolism, even before it arrives at the treatment plant, and deposit it as a black slime on a pipe interior. Such deposits can materially decrease the carrying capacity of the pipe.

Other methods of removal include: [1] oxidation with chlorine or chlorine dioxide, [2] base exchange, [3] aeration and contact-bearing ores, [4] use of the process developed by Carl Zapffe (*1*), [5] potassium permanganate treatment, [6] catalysis, and [7] ozone.

According to some authorities (*2*), the history of manganese removal can be divided into several distinct periods: bacteriological period (1836–1906); period of inorganic chemistry (1906–14); period of physico-chemistry (1914–22); period of catalysis (1922–30).

Since 1930 no designation has been given, but in view of the knowledge gained since then it appears that successful manganese removal depends upon the proper integration of the good

points of all known methods. It is now recognized that no single method mentioned in this article is the complete answer to the problem. It now appears that the "catalytic period" probably extended until about 1940. The period from 1940 to date could very well fall into the category of "period of oxidation (1940–)."

Conclusion

This article is a very sketchy outline of some problems that manganese either produces or accentuates. New problems are coming to the attention of experts in this field every week. Enough data have already been accumulated to allow the preparation of detailed reports on specific areas relating to the problem as a whole.

The importance of this problem is obvious. Manganese has caused difficulties in water supplies in all parts of the United States. One report (*3*) has shown that manganese has appeared in many water supplies after analysis of the raw water showed little or none of this material. Other literature in the field (*4–19*) reveals other important aspects of the problem.

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Determining Fundamental Chemistry of Manganese in Water Systems

Floyd I. Brownley Jr.

A paper presented on Apr. 24, 1958, at the Annual Conference, Dallas, Tex., by Floyd I. Brownley Jr., Prof. of Chemistry, Clemson College, Clemson, S.C.

MANGANESE in water frequently passes through treatment plants without being removed and is then precipitated in the distribution system, where it creates a number of problems. Manganese in untreated water is presumed to be in the manganous form, even though it may have been exposed to mild oxidizing influences previous to entering the water treatment plant. Little information is available on the form of manganese in various water sources (reservoir, stream, or well), within the treatment plant, or in the distribution system. The reactions of manganese under these conditions should be determined and simple methods of testing for the various forms of manganese ordinarily encountered in water purification should be developed.

In order to detect any changes in the chemical forms in which the manganese exists, tests would have to be devised to differentiate between the various valence states of manganese. A number of different laboratory tests have recently been tried. These tests have been run on samples containing various concentrations of the different forms in which manganese might possibly exist in natural waters.

Test Results

In the first attempt the polarograph was used. The sensitivity of this instrument was not great enough to detect the very low concentrations of manganese involved.

A number of chemical reagents have been used. The first of these was tetramethyldiaminodiphenylmethane (*1*), the so-called "tetra-base." This reagent was used in an effort to determine the manganous state only, and gave very poor reproducibility. In an effort to obtain better agreement between results, several analogous compounds were prepared, but these analogues gave no better results than the original base.

The acetyl acetone (*2*) method for distinguishing between trivalent and tetravalent manganese was investigated extensively. It was finally discarded as lacking sensitivity.

P-phenylenediaminehydrochloride has been used for a colorimetric determination of quadrivalent manganese (*3*). Other forms of maganese, however, caused appreciable interference in this test.

Other attempts have been made using several different reagents (*4–10*). All of these were discarded due to lack of sensitivity, interference by other ions, and other causes.

It has been determined that the manganous ion can best be determined by using pyrocathechol violet (*11*),

precipitating the quadrivalent form, and determining the ion gravimetrically. The permanganate and the manganous ion cannot exist together under ordinary conditions, so this determination should be sufficient. Check determinations can be made by determining total manganese.

Laboratory work will continue, and it is hoped that some simple colorimetric method may be evolved for these determinations. Bioassay methods will be tried, as well as redox potential measurements.

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Multiple Regression Analysis of Maximum-Day Water Consumption at Dallas, Tex.

Dan A. Brock

A contribution to the Journal by Dan A. Brock, Analyst and Statistician, City Water Works, Dallas, Tex.

RESEARCH into water system demands quickly becomes entangled with several factors. In the past, some investigators have studied and charted first one variable as an effect on water consumption, then another, and so on. A common example of this type of research is the plotting of daily water consumption against daily maximum temperature. Then, when temperature alone does not explain fluctuations in consumption, other factors, for example, cloud cover or previous number of days since rain, are introduced. When several variables come into the study, it becomes quite difficult to determine their joint effects. Consequently, the Dallas, Tex., water department has tried a somewhat different method of handling this joint-effect problem, and has also tried to achieve a more compact and coherent organization of both the analysis and the conclusions.

A technique of mathematical statistics, multiple regression analysis, was applied to the problem. This technique leads into necessary reduction of matrices (algebraic forms similar to determinants) of relatively high order (large size). The recently increased availability of electronic computers enabled the department to conduct its research in the manner just outlined.

Analysis of Consumption

The Dallas water utility has usefully completed an investigation of weather and other factors as effects on maximum-day water consumption. A magnetic-drum type digital computer performed the necessary calculations.

A day's water consumption is defined as the midnight-to-midnight total primary pumpage, plus the net loss or gain in reservoirs and tanks on the distribution system. An equation was derived which relates (with more than a 99 per cent probability) annual peak-day water consumption to heat and drought. Two more equations were derived which, at lower probability of significance levels, also relate maximum-day consumption to relative humidity and to the time (the trend).

Seven variables were used when data on peak-day summer water consumption in the years 1946–57 were investigated:

X_1—total installed water meters on May 31 (thousands)
X_2—maximum temperature on date (°F)
X_3—number of consecutive previous days with temperature over 100°F
X_4—number of weeks since 1 in. or more precipitation occurred in any 7-day period
X_5—minimum relative humidity on date
X_6—number of weeks since Mar. 21 (used for a season factor)
X_7—time in years since 1946 (used for a trend factor)

The prediction equations arrived at, with their associated probabilities of significance, are:

99 per cent level: $Y = -66.330 + 1.343X_1 + 0.680X_3 + 2.230X_4$

90 per cent level: $Y = -51.600 + 1.342X_1 + 2.330X_3 - 0.100X_3^2 + 1.410X_4 - 0.404X_5$

75 per cent level: $Y = -136.300 + 2.296X_1 + 2.330X_3 - 0.100X_3^2 + 1.240X_4 - 0.437X_5 - 0.738X_7$

TABLE 1

Projected Maximum-Day Consumption

Year	Consumption—*mil gal*		
	Max. Day in Dallas	Use in County Towns*	Total Primary Pumpage
Average Heat and Drought Conditions			
1957	184	9	193
1958	193	10	203
1959	201	10	211
1960	209	10	219
1961	217	11	228
1962	225	11	236
1963	233	12	245
Maximum Heat and Drought Conditions			
1957	205	10	215
1958	213	11	224
1959	221	11	232
1960	229	11	240
1961	237	12	249
1962	246	12	258
1963	254	13	267

* Based on 5 per cent of Dallas load, as was approximately the case in July 1957.

The first equation was used for purposes of prediction. For X values for different years, meters added were projected about as they increased in the past few years; for maximum drought conditions, X_3 and X_4 were used as they occurred in the driest, hottest year on record; for average load X_3 and X_4 were used as they averaged in the years 1946–57. Since the X_1 value of total meters installed is a substantial contributor to the predicted Y value, the formula could not be safely used to predict many years ahead. Actually, it might be desirable to recompute the whole equation every year or two. The actual computing machine costs to the utility on this problem were only $212.

A particular value of Y_{57} (Y for 1957) average conditions was computed as follows, with $X_1 = 175.780$ meters (in thousands), $X_3 = 4.711$ average number of previous days over 100°F, and $X_4 = 5.026$ average number of previous weeks without as much as 1 in. of rain in a 7-day period:

$$Y_{57} = -66.330 + 1.343(175.780) + 0.680(4.711) + 2.230(5.026)$$
$$= -66.330 + 236.073 + 3.203 + 11.208$$
$$= 184.154$$

For succeeding years X was increased each year by 6,000 water meters:

$$Y_{58} = -66.330 + 1.343(181.780) + 0.680(4.711) + 2.230(5.026)$$
$$= 192.212$$

Table 1 illustrates the use of the 99 per cent level equation.

The 75 per cent level equation is particularly interesting; the Dallas water department hopes to improve it and use it as more data become available. A second-degree (parabolic) time-in-years term might turn out to be more significant than the first-degree term used.

These equations were developed from data associated with conditions of weather, size and type of city, and other factors which may apply only to Dallas. The equations may, however, have some application in other cities.

Details of Analysis

This investigation was an extension to n dimensions of the common fitting of a line or curve to a scatter of points representing values of an independent variable. Where a dependent variable (Y) changes as one independent variable (X) changes, there appears the familiar two-dimensional graph of Y *on* X. Such lines are fitted to the scatter of points so that the sum of the squares of the lengths of the vertical deviations from the points to the fitted line is a minimum, hence the term "least squares analysis." Lines can be fitted to data simply by visual inspection as a line is drawn through the general center of groups of dots representing coordinate values of the dependent and independent variables. Mathematics can also be used to develop formulas which will give the parameters (also called constant coefficients or regression coefficients), with which a required line can be precisely drawn through the scatter of points. Most important, methods of mathematical statistics allow the fitting of the functions of any required degree, in any number of dimensions, and at the time test how well these functions represent the raw data (*1, 2*).

In this problem determination of ten regression coefficients for terms thought possibly significant was necessary. The basic equation was:

$$Y=b_0+b_1X_1+b_2X_2+b_3X_2^2+b_4X_3^2+b_5X_3 +b_6X_4+b_7X_5+b_8X_6+b_9X_6^2+b_{10}X_7$$

Only seven independent variables were used, but three of them were carried to the second degree. Terms were carried to the second degree where a noticeable tapering of an effect was expected. For example, consumption would be expected to increase in proportion to meters added; actually, consumption, with respect to heat, goes up sharply at first, then tends to stabilize. Preliminary investigation led to the elimination of cloud cover and day of the week from the analysis; the Saturday high-consumption effect has not been preeminent in the past few years.

Lack of a large volume of data somewhat hampered the analysis. The earliest maximum-day consumption figures for Dallas are for 1946. Eventually, peak or high-consumption days, or both, in June, July, and August were used to build up the total data to 38 sets of observations.

Two apparent factors which weakened the raw data somewhat were off-again, on-again lawn sprinkling restrictions, and physical restrictions when the utility was unable to supply the total demand for water.

Conclusions

Results of the electronic computer * run established the amount that maximum-day water consumption was affected by the total number of installed water meters, by the previous number of days over 100°F, and by the number of weeks since 1 in. or more of rain had fallen in a 1-week period.

A probable association was indicated between maximum-day water consumption and minimum relative humidity, time in years since 1946, and a second-degree term of previous days over 100°F. The associations at the 10 and 25 per cent levels of probability of occurrence, however, were not strong enough to justify using these

* IBM type 650, made by the International Business Machines Corp., New York. The Datics Corp., Fort Worth, Tex., ran this problem on IBM 650 computer for Dallas.

factors to predict maximum-day water consumption.

No association was shown between maximum temperature on date and actual consumption. This was rationalized on the basis that all of Dallas' peak-consumption days have temperatures over 100°F, and there is no significant difference in customer demand on days of, say, 103 and 107°F, other things being equal. An exception might be the factor of lower humidity on a hotter day. Some association of system load and humidity was shown.

The seasonal factor was not significant, probably because the true maximum-day consumption always falls within, approximately, a 6-week span in the summer.

The random variation expected in Y, where a set of X's is given, can be computed from the machine printout of the standard errors of Y. In Dallas, Y would be expected to be correct within about 6 mil gal, 95 per cent of the time, assuming the X's were correct.

The actual computer program used by Dallas is available to concerns using the same type of machine (*3*).

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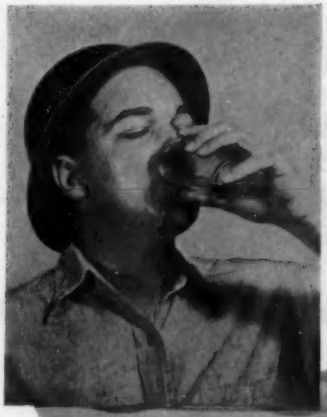

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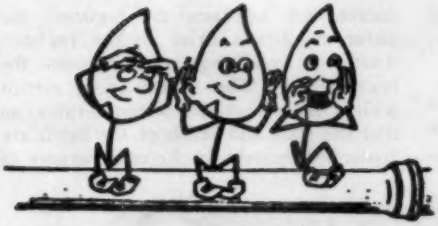


Percolation and Runoff

The weather bureau, whose all too frequent shortcomings we have been kind enough to ignore of late, has now gone just too far to let lie any longer. Apparently unable to do anything really effective about improving its reliability as a source of information concerning the prospects for picnics, golf, fishing trips, and other outdoor divertissement, it now has the temerity to suggest extending its "services" to measuring and reporting our discomfort. "D.I."—meaning "discomfort index"—is the term suggested by Julius F. Bosen, weather bureau meteorologist, for expressing the excruciating combination of temperature and humidity that usually characterizes New York summers, a value to be calculated by adding the wet- and dry-bulb temperatures, multiplying the result by 0.4, and adding 15. Just how the magic number that results will differ from the "humiture"—

$$\frac{\text{temperature (°F)} \times \text{relative humidity (\%)}}{2}$$

—introduced some years ago (see October 1954 P&R, p. 40) by a particularly sticky bank official, is not easy to see or, for that matter, to care about. True, humits and D.I.'s undoubtedly will show a direct correlation with water demand or pumpage—possibly even a significantly better correlation than temperature now does. But unless discomfort forecasting also proves significantly better than weather forecasting now is, the improvement in correlation will probably be lost through the neglect of such important psychological factors as the persistence of high-D.I.-ety, the trend of the stock market, and the position of, say, the Tigers in the American League. As for our own condition, we feel that an entirely subjective estimate of our comfort would be rather more descriptive than any plot of calculated D.I. against the average index of uncomfortability (70 D.I.'s or 70 humits). And, as a matter of fact, purely personally, now that it's a beautiful September day, we'd rather prefer to forget past and to avoid anticipating future discomforts regardless of their accuracy.

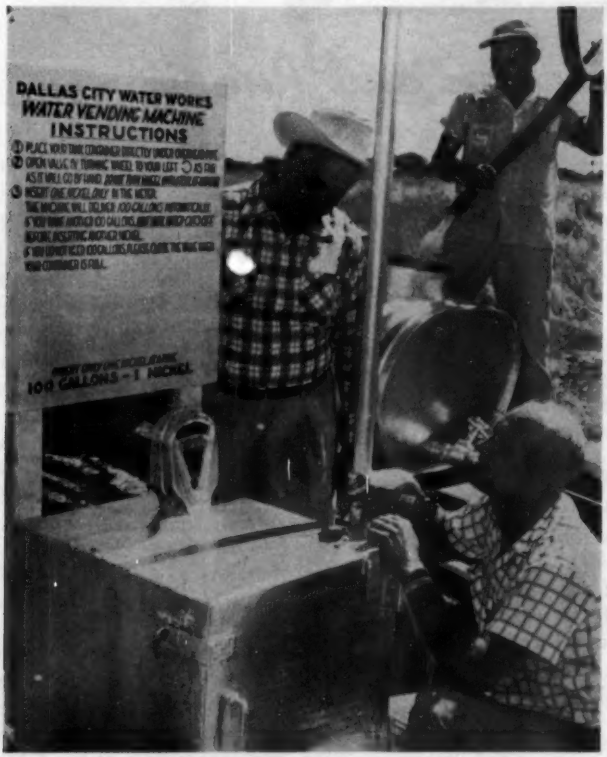
Vending machines have for some time been geared to sell anything from massages to milk shakes, from shoe shines to railroad tickets, from photographs to horoscopes, but, possibly for lack of coins of small enough denomination, water has not until very recently been mechanically vent. Now,

(*Continued on page 36 P&R*)

(Continued from page 35 P&R)

though, we are encouraged by word of two "real" slot-machine water purveyors.

The first of these is located at a small western England harbor, where small ships take on water. As described in the August issue of the Sparling Meter Co. newsletter:

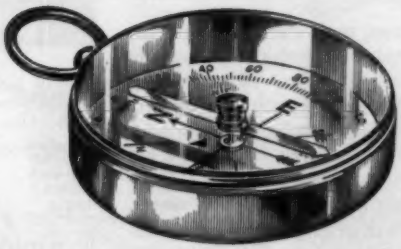


Courtesy Dallas Times Herald

A modified, well proved coin-slot mechanism receives two types of coin—a shilling or two shillings—and the register can be set to provide a "trip" at the end of any selected batch quantity. Insertion of the coin automatically trips a microswitch and sets the register; the meter supplies a drive to the register, which, on reaching zero, reopens the microswitch. The switch is in circuit with a servo-operated solenoid valve, so that the start and finish of the batch are controlled entirely by the coin register in conjunction with the meter. A second coin can be inserted while the first batch is flowing, and the additional prepaid quantity is added on.

But right here at home, in Texas, a device of much simpler design has been set up at the curb in front of the Dallas water department's Southwest

(Continued on page 38 P&R)



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(*Continued from page 36 P&R*)

Area Service Center office mainly to supply people who have to haul water when their wells go dry. Designed and built by Henry S. Richardson and W. H. Nottingham, water department mechanics, the Dallas vending machine was made from a second-hand parking meter set in concrete and attached to a motor-operated valve that is calibrated to dispense water at the same price that Dallas water customers pay for service at their homes—that is, 100 gal for a nickel. The simple operating instructions posted on the machine (see cut) read as follows:

1. Place your tank container directly under overhead pipe [which swings out on a crane to permit easy filling of tank trucks backed up to the curb].
2. Open valve by turning wheel to your left as far as it will go by hand. *Do not turn wheel with a tool of any kind!*
3. Insert *one nickel only* in the meter. The machine will deliver 100 gallons automatically. If you want another 100 gallons, *wait until water cuts off* before inserting another nickel. If you do not need 100 gallons, please close the valve when your container is full.

This could be the answer to practically all distribution system problems! All the water you need, when you need it—*Come and Get It!*

Corrosion and scale control in air-conditioning systems by chemical treatment of the circulating water is said to be facilitated with a "Chemistat" proportional feeder. The device (see cut), a development of Water Service Labs., Inc., New York, is designed to be put into a cooling tower or evaporative condenser, where it picks up water to dissolve a controlled amount of solid

chemical. The solution is then fed into the system automatically and continuously.

Plenty of nothing appears to have been made by a Houston, Tex., department long noted for giving plenty for almost nothing. Nothing—$0.00—at any rate, was the amount shown on the water bill received by a Houstonian last July. And nothing proved to be correct, as the meter had been incorrectly read the month before and the bill was sent merely to record the correction of the error. The "plenty" started to pile up, however, when nothing was done about paying the nothing. Not long after, the customer received a reminder notice warning him that unless nothing was paid promptly a penalty would be assessed. Probably fearing that the penalty might be a flat amount rather than a percentage of the bill, the customer rushed his check for $0.00 into the mail immediately, thereby also saving the penalty of $0.01

(*Continued on page 40 P&R*)

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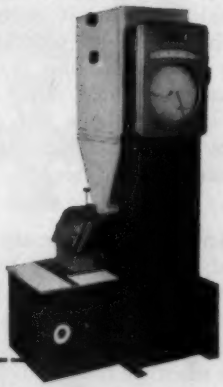

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Feeding principle: Gravimetric
Operation: Mechanical
Accuracy by wgt: ± 1%
Range: 100:1
Max. Cap: 500# per hr.
Accessories: Dust collector . . . chart recorder . . . remote or proportional controls

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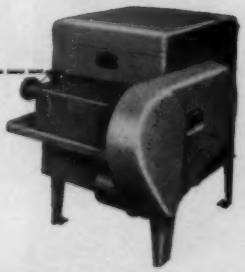
Omega Model 65 Rotodip — for feeding hydrofluosilicic acid.

Type of feeder: Dipper Wheel
Feeding principle: Volumetric
Operation: Mechanical
Repeatable Accuracy by vol: ± 1%
Range: 100:1
Max. Cap: 1800 gal. per hr.
Accessories: Remote or proportional controls . . . chart recorders



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B-I-F INDUSTRIES

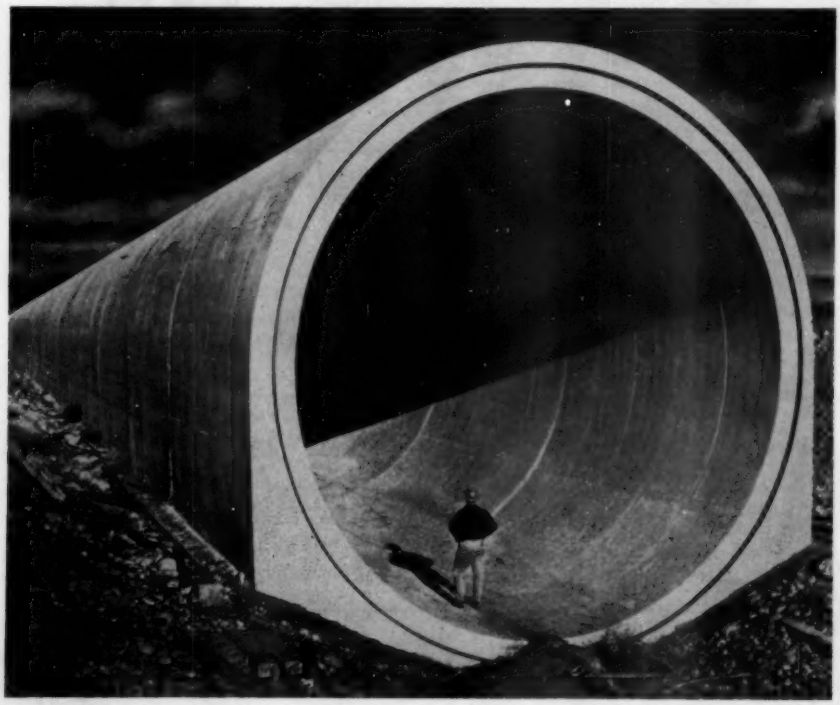
BUILDERS-PROVIDENCE • PROPORTIONEERS • OMEGA

(Continued from page 38 P&R)

that would have been levied by the postal authorities if he had waited until the first of the month. The *Christian Science Monitor* that printed this bit of "non-cents" didn't report it, but we certainly hope the water department took the opportunity to say: "Thanks for nothing!"

An ideal water main inspector is what we thought we had discovered when we spotted the picture below of "a man examining a water pipeline" constructed of Universal Atlas Cement. But when we offered to find him a job he turned out to be not a half pint at all, but a long drink of water (6 ft), the pipeline being the Dry Coulee Siphon No. 1, part of the West Canal of the Columbia Basin Project. The pipe is 25 ft in diameter, with a capacity of 5,100 cfs and an overall length of 4,545 ft. The sections are 25 ft in length with a wall thickness of 24 in. Actually, the line of which this section is a part was completed in October 1949, so he wasn't really available anyway.

Byron Bird, chief engineer, US Army Engineer Dist., Washington, D.C., has retired after serving in the Washington Dist. Office continuously since 1936.



(Continued on page 42 P&R)

TRINITY VALLEY

For All Cast Iron Water Works Fittings

AWWA Standard Bell Spigot Watermain Fittings—2" through 36".

Ring Tite Fittings 3" through 16" Class 150. Class 100 through 12".

Short Body and Mechanical Joint Watermain Fittings—2" through 20".

Fluid-Tite Fittings 3" through 12" Class 150.

TRINITY VALLEY IRON AND STEEL COMPANY

Phone PE 8-1925 Fort Worth, Texas P. O. Box 664

(*Continued from page 40 P&R*)

Tankless is the word for Ridgewood, N.J., now, thanks to neighboring Ho-Ho-Kus, on whose complaint the state supreme court ordered Ridgewood to dismantle and remove the 160-ft elevated water tank that it had almost completed a year ago (*see* September P&R, p. 64). And all that the tanklessness has cost Ridgewood is the $80,000 to erect the structure, the legal and court fees to defend it, and $100 to get a contractor to pull it down and take it away. The contractor, on the other hand, is not only tankful, but thankful, having sold the structure to the village of Oakland, N.J., for the bargain price of $50,000.

Courtesy Civil Engineering

Meanwhile, in nearby West Caldwell, N.J., other con-tankerous individuals, apparently emboldened by the Ho-Ho-Kusian coup, have brought suit against the Borough of Caldwell, the Essex Fells water department, and the local building inspector, contending that a 500,000-gal tank now just about completed "is located in a residential zone which does not permit operation of a water business and adversely affects property values." Although the object of this suit seems less tanklessness than bankfulness—each of some 50 property owners claiming about $500 in aesthetic damages—the result of the judgment against the department could well be less tanks in the future, to avoid the harassment as well as the unhappy public relations involved.

Where no tanks is not an answer, notable tanks may be—and we can think of no better example than the new 2.4 mil gal structure in Orebro, Sweden. Constructed of prestressed concrete, this 200-ft tower is in the shape of a champagne glass (see cut), the bowl 150 ft across, the hollow stem 35 ft in diameter. The finished tank has a restaurant on top, serviced by two elevators, and houses a radio and TV station. It is the shape, though, that really impresses us—how better suggest the exquisite taste of the product therein stored?

At any rate, it would seem these days that public pressure is at least as important as water pressure in the design and location of elevated tanks.

Johns-Manville has opened the first continuous-process asbestos-cement pipe plant in the United States. Located at Denison, Tex., the plant buildings cover 4 acres and include 186,000 sq ft of manufacturing and warehouse space. In the almost com-

(*Continued on page 43 P&R*)

NOW...a NEW MUELLER®

DOUBLE PRESSURE CHAMBER TAPPING MACHINE...

the B-100

MAKES FASTER TAPS!

ASSURES PRESSURE TIGHT CONNECTIONS!

PROVIDES EASY, TROUBLE-FREE OPERATION!

use it by hand or with power...

FORM NO. W-8912

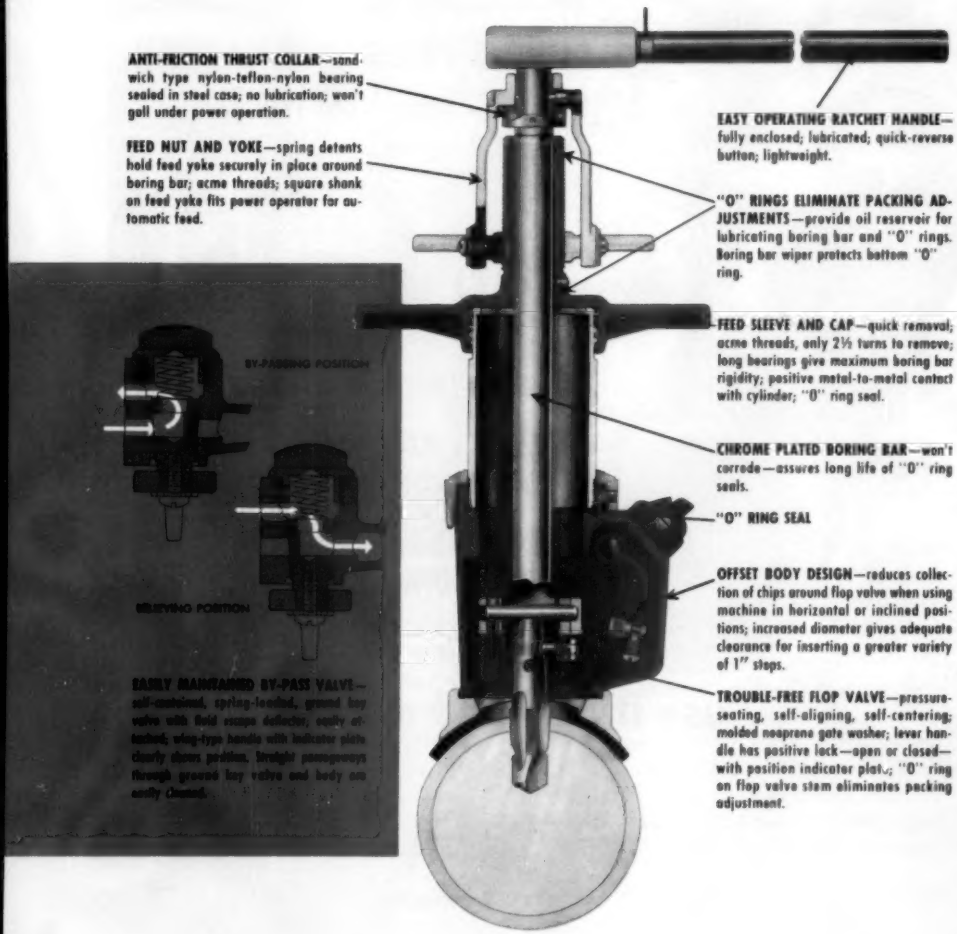
PRINTED IN U.S.A.

Features and Benefits

Fast taps, pressure tight connections and easy trouble-free operation provide an operating efficiency so necessary to meet today's demands. The new B-100 Drilling, Tapping and Inserting Machine gives these results IMMEDIATELY and CONSISTENTLY.

The machine incorporates the same basic double pressure chamber, single boring bar design principle which, through 86 years of field experience, research and testing, has proved to be the most efficient in operation. Its design permits the operator to handle the machine in lightweight sections. The tapping and inserting operations are performed separately. Tool or stop may be safely removed from the machine at any time during the operation for inspection or replacement, if necessary.

The "B-100" is *all new* from the saddle up, and has plus features we know you have wanted. Look over these features—see how they all combine to contribute to faster taps, pressure tight connections and easy, trouble-free operations.


ANTI-FRICTION THRUST COLLAR—sandwich type nylon-teflon-nylon bearing sealed in steel case; no lubrication; won't gall under power operation.
FEED NUT AND YOKE—spring detents hold feed yoke securely in place around boring bar; acme threads; square shank on feed yoke fits power operator for automatic feed.
EASY OPERATING RATCHET HANDLE—fully enclosed; lubricated; quick-reverse button; lightweight.
"O" RINGS ELIMINATE PACKING ADJUSTMENTS—provide oil reservoir for lubricating boring bar and "O" rings. Boring bar wiper protects bottom "O" ring.
FEED SLEEVE AND CAP—quick removal; acme threads, only 2½ turns to remove; long bearings give maximum boring bar rigidity; positive metal-to-metal contact with cylinder; "O" ring seal.
CHROME PLATED BORING BAR—won't corrode—assures long life of "O" ring seals.
"O" RING SEAL
OFFSET BODY DESIGN—reduces collection of chips around flop valve when using machine in horizontal or inclined positions; increased diameter gives adequate clearance for inserting a greater variety of 1" stops.
TROUBLE-FREE FLOP VALVE—pressure-seating, self-aligning, self-centering; molded neoprene gate washer; lever handle has positive lock—open or closed—with position indicator plate; "O" ring on flop valve stem eliminates packing adjustment.
BY-PASSING POSITION
RELIEVING POSITION
EASILY MAINTAINED BY-PASS VALVE—self-contained, spring-loaded, ground key valve with field escape deflector; easily attached; wing-type handle with indicator plate clearly shows position. Straight passageways through ground key valve and body are easily cleaned.

owners and operators will like...

REVERSIBLE POWER OPERATOR WITH AUTOMATIC FEED

Drill and tap a ¾" hole in three minutes, using the electric or air power operators, which are specifically designed for use with the B-100 Machine. No adapters or conversion parts are required. Either type of power operator attaches directly to top of boring bar and feed yoke. After hole has been drilled, loosen wing nut to release the automatic feed driver, then continue to make tap under power. After completing tap, flip the switch on the power operator to reverse direction of the motor and withdraw the tool under power. While drilling, boring bar feed is even and completely automatic—tool is not over-crowded; does not overheat; gives longer effective tool life.

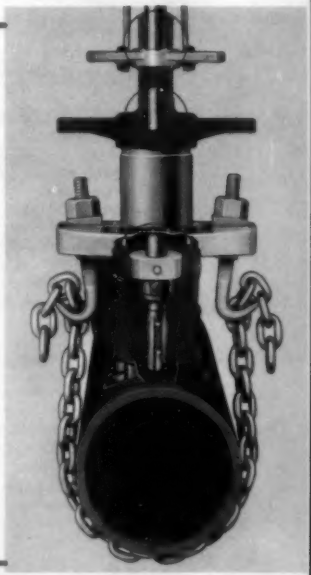
ASSURED RIGIDITY

ON THE MAIN

Pressure-tight connections start with complete machine rigidity on the main. Aluminum alloy chain yoke has high strength —lightweight. Chain hook washers are widely spread and deeply recessed in yoke to prevent slipping off on large diameter pipe. Chain hook cannot rotate—chain cannot twist during tightening. Square shank on chain hook fits inside square hole in chain washer. Square shank on chain washer prevents turning in yoke. Acme threads on chain hooks give long life. Chain hooks, chain hook washers and chain hook nuts are cadmium plated to resist corrosion.

IN THE BORING BAR

Perfect alignment of the boring bar is assured by three boring bar bearings; two, widely spaced in the feed sleeve, and the third at the extreme bottom end of the boring bar. The lower bearing is of molded nylon and closely bears against a machined surface in the body when the drill first contacts the main and also when the stop is being inserted. Curvature of the pipe cannot deflect the drill—tools are relieved of unnecessary stresses and give longer effective life. These three widely spaced boring bar bearings assure perfect centering of tool and stop for accurate threading and a pressure-tight connection.



NEW TOOL RETAINER WITH INDEPENDENT DRIVE

Drive pins in shank of new combined drill and tap or E-Z Release Screw Plug slip into notches in the boring bar socket. All driving force is exerted against these drive pins, preventing damage to the surface of the tool shank. Tool retaining screw in replaceable bronze sleeve bears against the upper part of a circular groove around tool shank—holds tool tight in boring bar socket. This new holding and driving arrangement assures perfect tool-boring bar alignment and maximum rigidity, for long tool life.

No problem to remove tools in the "B-100". Just loosen the tool retaining screw, tap the knockout pin in the tool holder and the tool slides out in your hand.

MUELLER®

B-100 DRILLING, TAPPING AND INSERTING MACHINE

CAPACITY AND USE

The B-100 Machine will drill and tap the main and insert the following items under pressure: corporation stops and gas main stops ½" through 1"; machine inserted valve tees ¾" and ¾"x1"; and pipe plugs ½" through 2½".

Combined drills and taps and screw plugs are not interchangeable between the B and B-100 Machine. Saddles are interchangeable with the B Machine.

WORKING PRESSURE

90 p.s.i. without power clevis.
250 p.s.i. with power clevis.

B-100 MACHINE AND EQUIPMENT FURNISHED

- Ratchet handle
- Small saddle gasket
- Large saddle gasket
- Chain hooks and nuts
- Chain washers
- Round link chain
- Chain hook nut and tool retaining screw wrench
- Body cleaning chisel
- Lubricating oil
- Cutting grease

Shipped in strong wooden chest. Total shipping weight 97 pounds.

Handling weight during operation: upper section 19 pounds; lower section 23 pounds.

EQUIPMENT TO BE SELECTED

- Combined drills and taps
- Saddles
- Screw plugs
- Extracting tools

OPTIONAL POWER OPERATORS

Electric or air power operators are offered as optional equipment for use with the B-100 Drilling and Tapping Machine. Either unit is suitable for 1" taps through any kind of pipe. Drive spindle turns at 35 r.p.m.—motors are reversible.

H-603 ELECTRIC POWER OPERATOR
110-120 volt A.C. or D.C.

H-604 AIR POWER OPERATOR
90 p.s.i. pressure (full load)

OPTIONAL EQUIPMENT FOR SPECIAL USES

- Power clevis
- Chain spreader
- Corporation stop wrench
- Round link extension chains
- Long Ratchet Handle Bar (used for drilling and tapping operations on cuts over 1" in size).

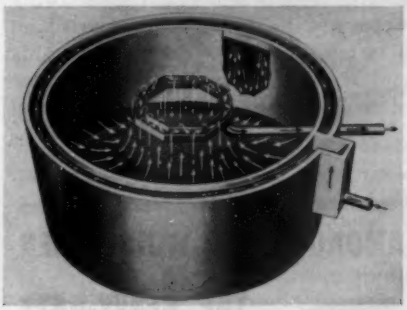
Since 1857 Serving the Water and Gas Industries

MUELLER CO.
DECATUR, ILL.

Factories at: Decatur, Chattanooga, Los Angeles.
In Canada: Mueller, Limited, Sarnia, Ontario

(Continued from page 42 P&R)

pletely automatic, electronically controlled factory, the continuous-process machine transfers a wet asbestos-cement mixture to a felt roll which carries it to steel mandrels where the "pickup" on the felt is transferred, under pressure, in a laminating operation that forms the cylindrical pipe. Continuous processing is made possible by a double press section arrangement that allows formation of pipe at two alternating stations to which pipe mandrels are magazine fed automatically—an operating principle roughly similar to that of the old Gatling gun.



A clarifier said to be unique in its employment of a peripheral flow pattern has been introduced by Chain Belt Co., Milwaukee, Wis. As the simplified cutaway view shows, the Rex "Rim-Flo" unit makes use of a feed channel passing entirely around the periphery of the tank. The advantages over conventional circular clarifiers are said to include lower inlet velocities, more complete utilization of tank volume, greater settling efficiency, and improved economy of operation. It is claimed that the flow principle is applicable to tanks of any size and that existing tanks can usually be modified to incorporate it.

Nehru and the US Marines, two mighty potent forces, were almost over their heads in water supply last August at almost opposite ends of the globe.

It was the failure of the New Delhi water supply for 22 hr that got Nehru into deep and hot water, causing the speaker of India's parliament, for the first time in that body's 30-month session, to permit a vote on a motion for adjournment—a form of censure of the government. Although the motion failed by a vote of 161 to 46, water supply was, nevertheless, established as the first issue in that period considered worthy of threatening a change in the government.

As a matter of fact, Indian hot water over water supply is not confined to New Delhi. In water-short Jodhpur, especially, the situation is bad—so bad that residents are training vicious stray dogs to serve as bodyguards during fights for water at the public hydrants. The dogs, on what must be a new kind of hydrant patrol for them, help their masters protect their places in line and also assist in any fighting that develops. The extent of their participation may be judged by the fact that as many as 70 people have received antirabies shots in a single day at the local hospital. Even in the land of passive resistance, apparently, water isn't something one can sit back and wait for.

Meanwhile, those anything but passive resisters—the Marines—were getting into international hot water for "violating Cuban sovereignty" to protect the water works that supplies their Guantanamo Bay base against "rebel" raids. Although the Cuban govern-

(Continued on page 44 P&R)

(*Continued from page 43 P&R*)

ment granted the Marines permission to take up the guard duty when its own soldiers left, Fidel Castro and his Civic Revolutionary Front could see this as nothing but helping Batista by relieving his troops. Nor did Moscow miss the opportunity to assail the "blatant violation of international law." There, too, the situation eased before the water got too deep, when, a couple of days later, Cuban troops resumed their guard duty and permitted the Marines to "fall back," as the newspapers called it, to their own territory.

What price water?

Booming was the word for the water business in Belleville, Ill., last Jul. 24, and it wasn't just heat, but ignition as well, as the water mains were invaded by gas which caused explosions and fires in six locations and threatened many more. First word of the invasion came from a local bottling plant, which sent an emergency call to the water company when its faucets and bottling machines began to spout gas instead of water. Even before a radio car could reach the scene, the first of the series of explosions had punctuated its progress. And when a hydrant was opened to fight the resulting fire, it, too, sent out a stream of high-pressure gas instead of water. The other five blasts followed rapidly before the water company was able to issue a radio warning against drawing water and to get its crews started on a systematic plan of flushing hydrants and services to release the gas. One of the first hydrants to be opened

(*Continued on page 46 P&R*)

LaMOTTE CONTROLS

have served the Water Works Engineer for more than 35 years.

Have you sent for the latest booklet on this helpful LaMotte Service?

***For example*—did you know that the LaMotte-Pomeroy Sulfide Testing Outfit determines accurately:**

- **Total Sulfides • Dissolved Sulfides • Hydrogen Sulfide in Sludges and Solutions • Free Hydrogen Sulfide in Air and Gases? •**

We will be happy to send full information on this and other LaMotte units used in the Water Works field.

LaMOTTE CHEMICAL PRODUCTS COMPANY

Dept. AWWA Chestertown, Md.

AMONG WATER WORKS MEN

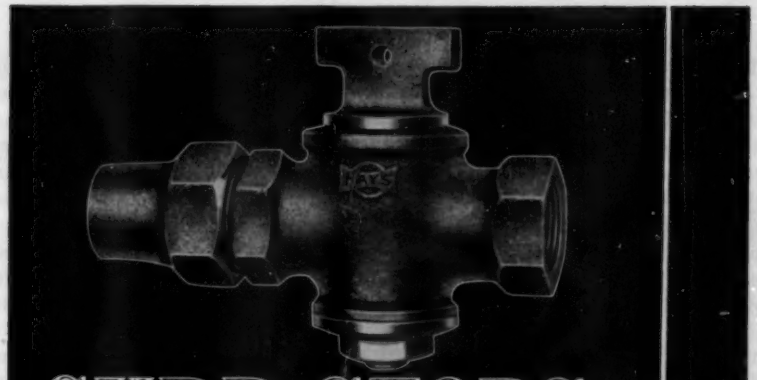
THE HEAVY-DUTY ELLIS PIPE CUTTER IS *BEST*

FOR CUTTING LARGE SIZES OF PIPE

No. 01 Cuts Pipe 4" to 8"
No. 1 Cuts Pipe 4" to 12"

Write for circular and price list No. 40J on our complete line of pipe cutting tools.

ELLIS & FORD MFG. CO.
1100 Coolidge Rd. P.O. Box 308
Birmingham, Michigan



CURB STOPS.

It Pays to Buy

HAYS

High quality water service bronze, 85-5-5-5 mix . . .
A full line of types and sizes for every need . . .
Plugs individually ground in for perfect fit . . .
Every stop individually tested . . .
Threads interchangeable with those of other manufacturers . . .
Backed by more than 80 years' experience . . .
Conform to all A.W.W.A. standards.

The same quality is maintained in the complete HAYS line of Water Service Products. Send for literature.

COPPER METER SETTERS

MODEL "B" TAPPING MACHINE

CORPORATION STOP

DUO-STOP CORPORATION STOP and SADDLE COMBINED

Increasing sales of HAYS quality products enables us to enlarge our sales force. Write us if you are interested in selling for HAYS.

HAYS

WATER WORKS PRODUCTS

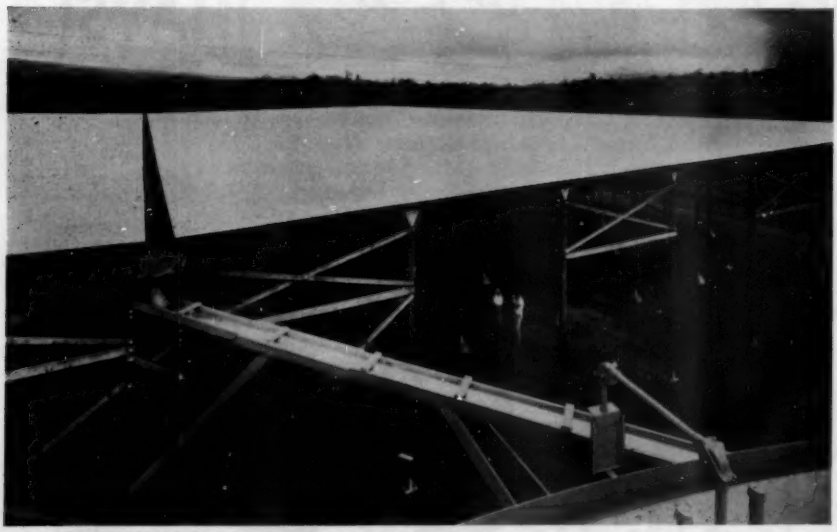
HAYS MANUFACTURING CO.

ERIE, PA.

(*Continued from page 44 P&R*)

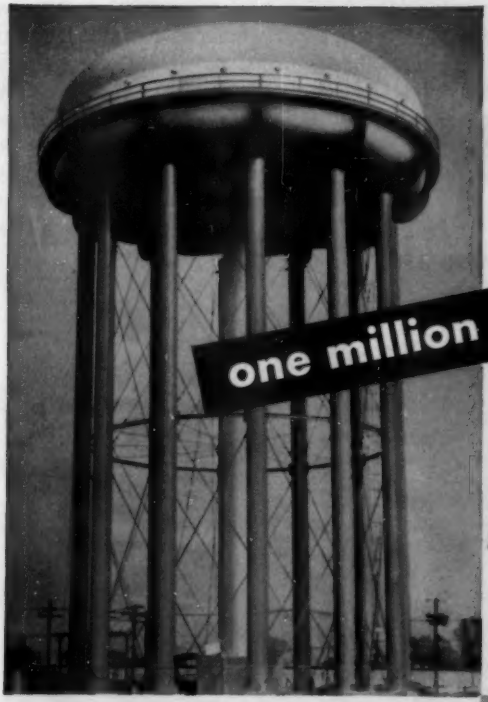
flowed gas for a full 4 min before any water came, and then the water remained milky for 2 hr, but, by evening, except for a few pockets that showed up later, the system had been pretty well cleared by the flushing procedure.

Actually, the cause of the trouble was not discovered until the following day despite the combined detective abilities of the water company staff, representatives of the local and state health departments, and fire department personnel. First suspect involved was the water distribution system. Although the normal pressure of 40–50 psi would be more than enough to repel any invasion from the 6-psi gas system, it was thought that a break in the mains might have lowered the resistance enough to permit entry of gas. This possibility was quickly eliminated by a pressure test. A simultaneous check with the gas company also provided no clue to the difficulty. Then a health department analysis of the gas itself proved that it was not from the gas system, but propane. This sent water company crews on a house-to-house check for cross connections, but again results were negative. Finally, through an anonymous tip to the fire chief, it was found that a commercial trucking company employee had accidentally created a cross connection



This huge new aluminum water catchment collects more than 27,000 gal of water per inch of rainfall in the Kilauea section of Hawaii National Park. Covering an area of approximately an acre, the shed consists of two 100 × 200-ft portions covered with Kaiser Aluminum corrugated 0.024-gage roofing sheet. Water drains at the center into a 22-in. diameter aluminum flume connected to an adjoining reservoir.

(*Continued on page 48 P&R*)



HAMMOND
PROVIDES
one million gallons
of
WATER STORAGE
for
ALEXANDRIA, LA.

HAMMOND Standpipes, Reservoirs, Elevated Tanks, Spheres, Filtration and Purification Units for Water Supply & Fire Protection Systems are built to all standard codes and specifications including those of the American Water Works Association, Associated Factory Mutual Fire Insurance Companies, the National Board of Fire Underwriters, the Factory Insurance Association.

Catalog H_2O details and describes all **HAMMOND** Water Storage and Processing Vessels . . . Write for your copy.

Alexandria, La.
Radial Cone Elevated Water Tank

Capacity	1,000,000 Gal.
Tank Diameter	86 Feet
Range of Head	25 Feet
Tower Height	113 Feet

consulting engineer
H. L'Hoeureux & Assoc. Alexandria, La.

HAMMOND IRON WORKS

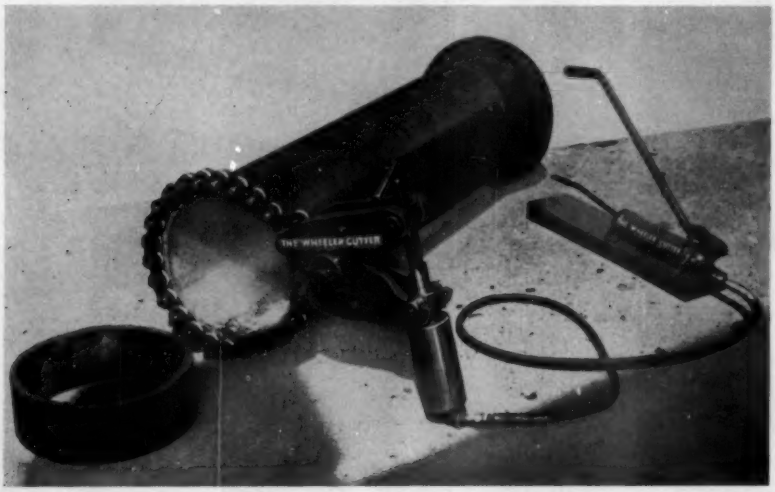
WARREN, BRISTOL and PITTSBURGH, PA.
PROVO, UTAH • CASPER, WYO. • BIRMINGHAM, ALA.

Sales offices throughout the U.S.A.; licensees and sales offices in many foreign countries including Argentina, Belgium, Brazil, Canada, Colombia, Egypt, England, France, Haiti, Italy, Japan, Mexico, Netherlands, Peru and West Germany

(Continued from page 46 P&R)

when he hooked the hose of a supposedly empty propane tank truck to the water line in an effort to flood the tank as a safety measure before doing a welding job on it. Apparently the hookup between the tank, carrying gas at 95–125 psi, and the main, at 45 psi, was maintained for 20 min before the employee discovered gas escaping from a toilet bowl that had been flushed. The connection was then broken, but the accident was not reported.

A review of the incident after the gas and the mystery had cleared showed that five homes and a store had been damaged by explosion and fire; four persons had been injured, though none seriously; 2,500 residents in a 50-block area had been ordered out of their homes for a 6½-hr period, and others for shorter periods; and the personnel of the East St. Louis & Interurban Water Co. and cooperating organizations had been on an emergency schedule for more than 24 hr. Actually, compared to the possibilities, these consequences were relatively insignificant, thanks primarily to the prompt action of the water company staff under the on-the-spot supervision of J. W. Lawrence, assistant manager, but the possibilities should be enough to frighten anyone. Meanwhile, it seems that one man's safety can be another's hazard!



A hydraulic cutter for 4–12-in. cast-iron pipe (plain or cement lined) or 6–10-in. asbestos-cement pipe has been placed on the market by Wheeler Mfg. Corp., Ashtabula, Ohio. In operation, the chain is wrapped around the pipe and pulled through the jaws to the nearest ring (see photo). The adjusting screw is tightened to take up slack, and hydraulic pressure is applied by a hand or electric pump. The device is said to produce a clean, accurate cut in less than a minute and to operate, without vise or turning, on

(Continued on page 50 P&R)

Dallas, Texas, one of the fastest growing cities in the Southwest, is making sure that no water shortage will impede its progress.

Since 1946, Dallas has laid each year better than 100 miles of mains from 4" to 72" in diameter. This long-range program has enabled Dallas to provide for all present water needs, despite explosive population growth and a rise in water consumption from 44,000,000 gallons daily in 1946 to 86 million gallons today. It has likewise proved a fortunate factor in meeting the prolonged drought that hit the Southwest.

Today the progressive Dallas Water Department under the direction of its able superintendent, Mr. Henry J. Graeser, is taking a real long look into the future. It is making feasibility studies of new water sources that will continue to support the water needs of Dallas in the year 2000!

If your community expects to keep on growing, now is the time for long-range planning of water main extensions with—

Permanent CAST IRON PIPE

This is the only pipe that has stood the test of time. Because of its century or more of useful life, its high capacity as a carrier and minimum maintenance cost. Cast Iron Pipe has rightly earned its reputation as: "America's No. 1 Tax Saver."

Our Company does not manufacture Cast Iron Pipe but has long supplied the nation's leading foundries with quality pig iron from which quality pipe is made.

WOODWARD IRON COMPANY
Since 1882
WOODWARD, ALABAMA

(Continued from page 48 P&R)

pipe in a ditch or line, provided the chain can be wrapped around it. Price is $352.50.

Legal notes: *Permit power.* A small privately owned water company operating in Oakland County, Mich., desired to expand its service and applied to the State Health Dept. for a well permit. Although the department regarded the well supply as of doubtful reliability, it granted the company a temporary permit—to expire in 3 years, or sooner if the Southeastern Oakland County Water Authority became able to furnish the company with water. This, in fact, occurred, but the company refused to abandon its well supply and asked the Michigan Supreme Court to force the health department to extend its permit. The court ruled in favor of the health department, holding that the company, by accepting the limited permit, had assumed a contractual obligation to comply with its provisions.

Fluoridation. According to a recent enactment by the state legislature in Massachusetts, no municipality (or district) can initiate fluoridation without approval by a majority of its citizens at a referendum. In New Hampshire, under a law passed last year, a public hearing must be held by a municipality before fluoridation can be undertaken.

The new "Read-o-Matic" register developed by Badger Meter Mfg. Co., Milwaukee, Wis., brings water meter reading "out in the open." A simple doorbell type of wire connects the meter and the remote-reading register, which, it is claimed, can be placed ½ mile away without loss in accuracy. The extremely low voltage of the self-powered register permits safe, unrestricted installation. No outside power source is needed.

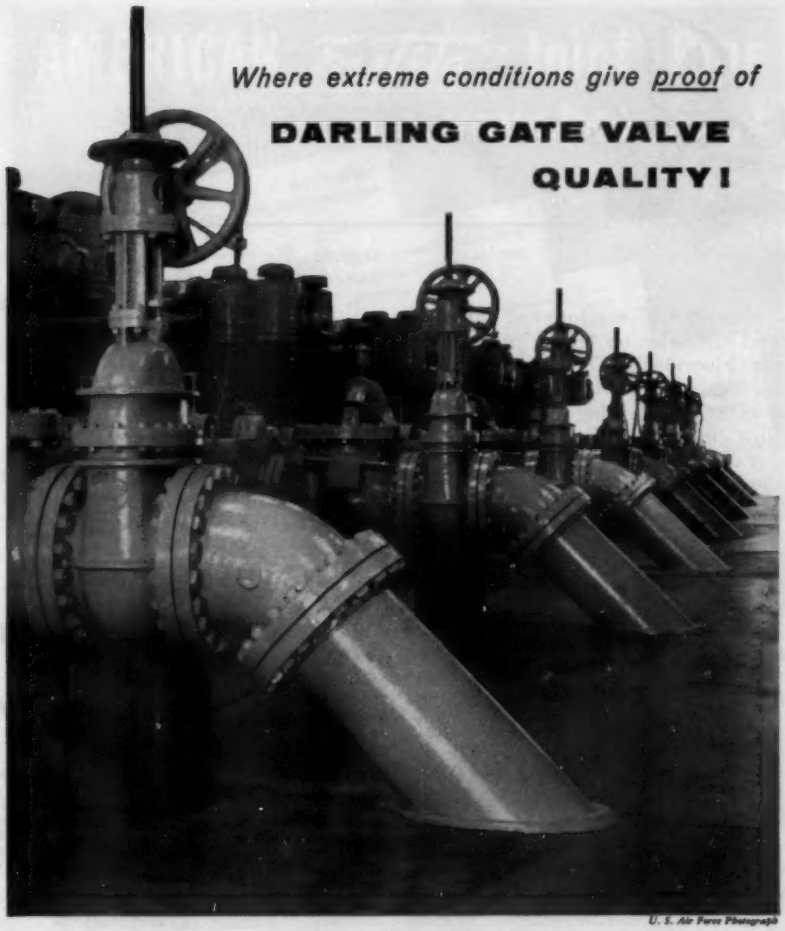
Philip N. Engel, chairman of the board, Infilco Inc., Tucson, Ariz., died May 26, 1958. After attending Armour Institute of Technology, he joined his father's small firm, International Filter Co., and inaugurated a research and development department—a step which contributed largely to the company's subsequent growth. In 1905 he succeeded his father as president of Infilco, a post he held until he became board chairman in 1957. He was a Life Member of AWWA, having joined in 1919.

Lloyd George, Indianapolis, Ind., representative of Mueller Co., died accidentally Jul. 1, 1958. He was 58. Mr. George had been a member of AWWA since 1940.

(Continued on page 102 P&R)

Where extreme conditions give proof of

DARLING GATE VALVE QUALITY!



U. S. Air Force Photograph

From zero to 30,000 gpm demand...suddenly!

Fast pressure changes and heavy line surges are the rule in this system supplying water to the rocket launching pads at a large Air Force test center. The Darling valves installed here must take this severe service in stride . . . and still continue indefinitely to provide smooth, positive response!

There are a number of Darling valve features that assure such performance—features that can help avoid trouble and maintenance in your service, too! For example there's the automatic seating compensation, uniform wear distribution and drop-tight closure assured by Darling's unique gate principle with its fully revolving double discs and parallel seats. You are certainly welcome to complete data on Darling gate valve features, sizes and types. Get *all* the facts! Send for Bulletin 5710.

DARLING VALVE & MANUFACTURING CO.
Williamsport 23, Pa.
Manufactured in Canada by The Canada Valve & Hydrant Co., Ltd., Brantford, Ontario

DARLING VALVES

Correspondence

Fluoreduction

To the Editor:

In October 1957 the JOURNAL published a panel discussion on "Experience in Applying Fluorides." One of the participants, Benjamin C. Nesin, asserted that: "An extensive sampling study in a New Mexico city, over a 6-month period, revealed a highly erratic pattern" of fluoride concentrations. "Fluoride values ranged from 0.0 to 3.2 ppm, when they should have been 0.8, plus or minus 0.1 ppm."

I have investigated the statements made by Mr. Nesin on New Mexico, and I can find no basis for them. The only New Mexico cities fluoridating their water are Santa Fe and Raton. Daily fluoride concentrations in raw, treated, and distribution system water are checked by the water departments of the two communities. In addition, sample checks are made by the New Mexico Department of Public Health Laboratory on the results of the water departments. These records indicate that, in both Santa Fe and Raton, fluoride concentrations were always 1.0 ppm or below during the period covered in the panel discussion in the October 1957 issue.

We believe that New Mexico fluoridation practice has been grossly misrepresented. We hope that you will take steps to remedy the situation.

ROBERT P. LOWE

Asst. Director, Environmental Sanitation Services, New Mexico Dept. of Public Health

Santa Fe, N.M.; Jul. 10–Aug. 13, 1958

To help set the matter straight, we are not only publishing the above letter, but also including a correction notice in the text section of this issue (p. 1385).—ED.

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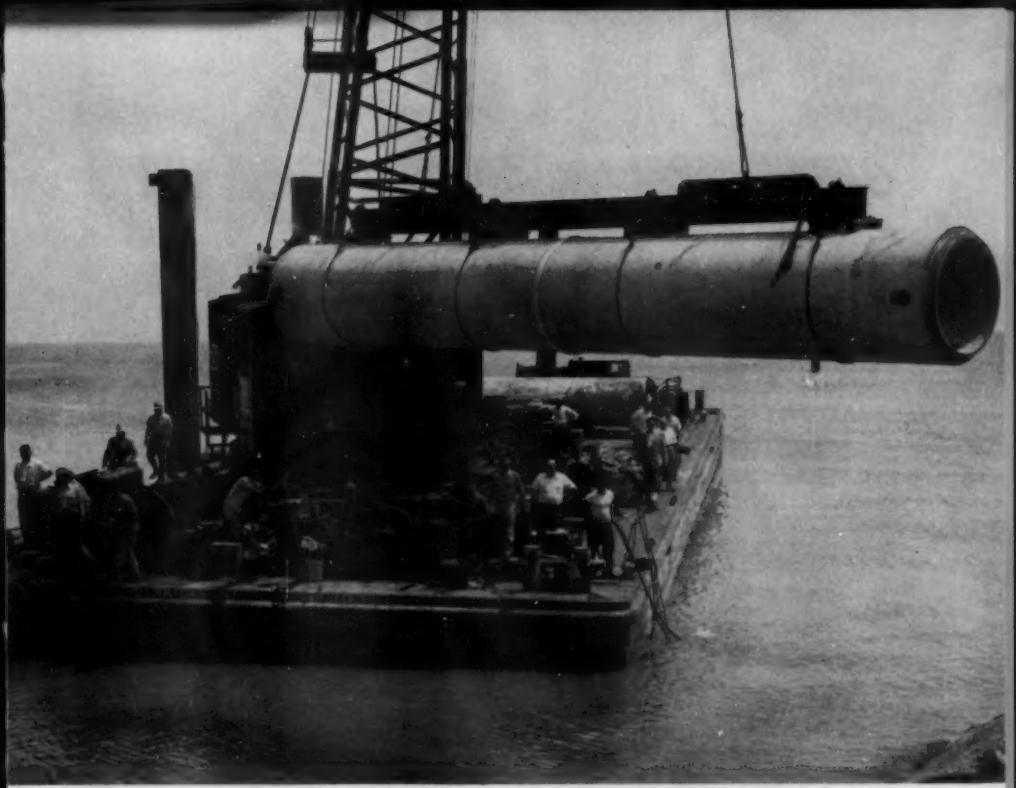

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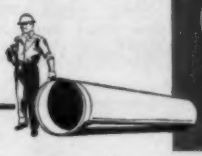

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

AQUATIC ORGANISMS

The Communities of Algae in the Springs and Spring Streams of Florida. L. A. WHITFORD. Ecology, **37**:433 ('56). Evidence is presented that there are following types of Fla. springs, as indicated by water qual. and algal flora: hard, fresh-water; oligohaline; mesohaline; and sulfide. There are probably 2 other types: soft, fresh-water; and mesohalinesulfide. There is 1 important algal community in each type of spring and its run, or stream—lotic aufwuchs (or periphyton) community in which diatoms are usually dominant. Importance of current in constantly renewing minerals and gases at plant surfaces is emphasized. Following algal communities are recognized: (1) *Cocconeis-Stigeoclonium* community of hard, freshwater springs. (2) *Cladophora-Cocconeis-Enteromorpha* community of oligohaline springs. (3) *Enteromorpha-Lyngbya-Licmophora* community of mesohaline springs. (4) *Phormidium-Lyngbya* community of sulfide springs. Species of algae attaching to various types of substrata are given as well as succession on young to older leaves.—*PHEA*

Studies on Deep Mass Culture of Algae in Israel. A. M. MAYER; A. EISENBERG; & M. EVENARI. Sci. Monthly, **83**:198 ('56). Deep unit for mass culture of algae is described. Cheap method of agitation has been developed. Yields as high as 21 g. (dry wt.)/sq m of illuminated area/day have been obtained. Yearly avg. for 3 algal species gave 16-g. Yields calcd. theoretically from actual yield are as high as 32 g. Suitability of Israel for mass culture is pointed out. It is considered that present results bring mass culture of algae toward borderline of economic feasibility. Its practical feasibility may be taken as established.—*PHEA*

Coliform Bacteria in Sediments Around Three Marine Sewage Outfalls. S. C. RITTENBERG; T. MITTWER; & D. IVLER. Limnology and Oceanography, **3**:101 ('58). Distr. of coliforms in sediments around 3 marine sewage outfalls was investigated. It was found that coliform fields extended for considerable distances around 2 outfalls discharging unchlorinated primary treatment effluent and that less extensive field existed around outfall discharging more highly treated sewage. In general, coliforms in sediments were found in areas beneath path of movement of effluent field in surface water. It is probable that bulk of coliforms reach sediments by sedimentation from overlying waters. Although coliforms in sediments must persist for sufficiently long period to permit accumulation of large nos. by deposition from low-count waters, no precise est. of survival time in sediment could be made.—*PHEA*

On the Absolute Viability of Certain Pathogenic Bacteria in a Synthetic Well-Water. J. F. D. SHREWSBURY & G. J. BARSON. J. Path. Bact. (London), **74**:215 ('57). Authors describe expts. to det. viability of *Salmonella typhi, Shigella boydi,* and *Vibrio cholerae* in synthetic well water. Concns. of salts in well water were same as those in the water of Hagar's well, Mecca. Water had pH value of 5.6. Expts. were repeated using *Shigella sonnei, Sh. shigae, Sh. flexneri* W, *Sh. boydi, Salmonella typhi* and *V. cholerae* in neutral and alk. waters. Results of viability tests and of agglutination tests are given in tables. It was found that temp. and pH value of water are important factors affecting viability of these bacteria. Under suitable conditions, dysentery bacteria can survive in water long enough to cause water-borne epidemics of dysentery but brief viability of *Vibrio in* water of poor qual. suggests that water is

(Continued on page 64 P&R)

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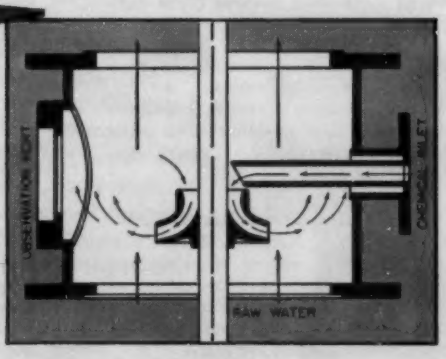

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(*Continued from page 62 P&R*)

not optimal means of transmission of cholera, although water-borne epidemics of cholera are known to have occurred.—*WPA*

Mortality of Carp Fry Due to Infection by a Parasitic Ciliate. S. J. KARAMCHANDANI. Current Sci. (India), **25**:126 ('56). Investigation was carried out during period Jun.–Jul. '52 on R. Ganga at Dighwara (Bihar), India, to ascertain availability of fish seed of major carp. During investigations, mortality of carp fry was observed among carp reared in glass jars in field lab. This was found to be due to infection by parasitic ciliate *Trichodina* species. Sample of 100 carp fry from collections were kept in clean glass jars and fed on plankton. After 1 day several carp died due to injury and shock of collection and segregation. Next day, over 50% of carp died. As carp recover from shock of removal in 24 hr, this was due, therefore, to presence of parasite. *Trichodina* occurred on or near fins of fish. It was thought that infection had come from plankton or river itself, as parasite is capable of free living. Other cases of carp mortality due to infection by *Trichodina* are mentioned, and it is thought that poor yield of carp fry from nurseries in India is probably partly due to mortality caused by parasitic infection.—*PHEA*

Studies on Bovine Leptospirosis. III. Isolation of *Leptospira pomona* from Surface Waters. R. W. H. GILLESPIE ET AL. Am. J. Vet. Res., **18**:76 ('57). 5 strains of *Leptospira pomona* were isolated in pure culture from surface of stagnant, marshy, and also rapidly flowing waters in 4 different dist. Waters had been in contact with cattle suffering from leptospirosis. Source was probably urine of cattle.—*WPA*

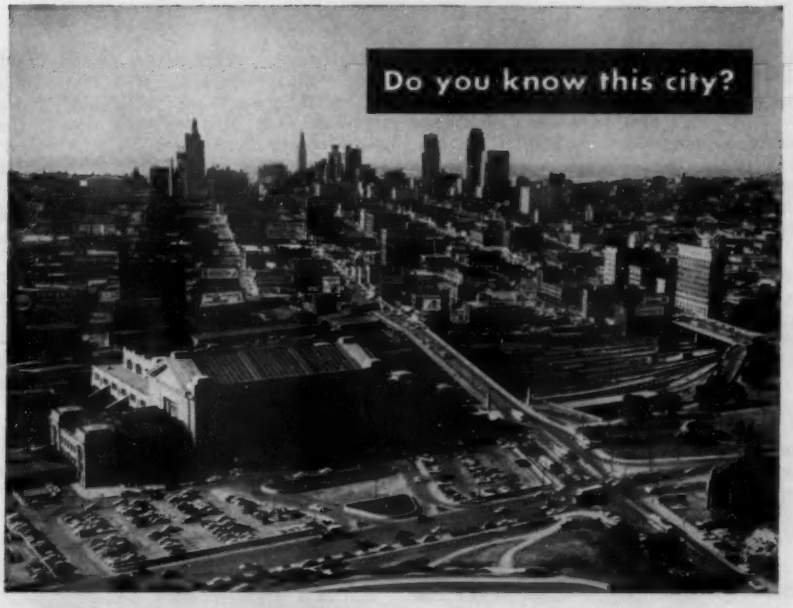
Fresh Water Mollusks and Stream Pollution. C. B. WURTZ. Nautilus, **69**:95 ('56). Results of literature survey revealed that 14 species of pelecypods and 20 species of gastropods showed some deg. of tolerance to poln. Snail *Physa heterostropha* was most tolerant species of mollusc.—*PHEA*

Some Researches on the Control of Mussels in Water Pipes. F. GREENSHIELDS & J. E. RIDLEY. J. Inst. Wat. Engrs. (London), **11**:300 ('57). Small-scale expts. were carried out over period of 3 yr by Metropolitan Water Bd. to det. most effective dose of chlorine for clearing infestations of *Dreissensia polymorpha* in water mains. Mussels, obtained from inlet channels of primary filtration plant, were placed in wooden or plastic trays inside covered asbestos or porcelain tanks. Unfiltered Thames water was passed through tanks at rate of about 30 gpm and chlorine was added to give predetermined chlorine/chloramine residuals varying from 0.25–20 ppm after 5 min of contact, for period of 7 days. After 7 days of chlorine treatment, and at intervals of 7 days after end of treatment, mussels were examd. and percentage mortality detd. Results, which are given in form of graphs and table, show that the death rate is greatest during summer mos. for all chlorine doses. Concns. of 2 ppm and 0.5 ppm residual chlorine are suggested for clearing and preventing reinfestation of main, respectively, and it is recommended that dose should be built up gradually over 3 days if main has received no chlorine for several mos. Anal. of Thames water used in these expts. is given.—*WPA*

The Qualitative and Quantitative Distribution of Plankton in the Strait of Georgia in Relation to Certain Oceanographic Factors. J. E. H. LEGARE. J. Fisheries Research Board Can. (Can.), **14**: 521 ('57). Survey was made of plankton communities in Strait of Georgia, B.C., Can., in Jun. and Nov. '55, to det. seasonal variations. Principal factor affecting general distr. of plankton is salinity gradient. Inflow of fresh water from Fraser R. forms zones of varying properties and leads to development of different plankton communities. Extent to which phys. and chem. factors may det. presence or absence of certain organisms from zones described is discussed.—*WPA*

Morphometric Studies With *Daphnia Longispina* and Quantitative Researches on the Zooplankton of the Red Sea. K. WOLF. Schweiz. Z. Hydrol. (Switz.), **17**:217 ('55). Morphometric researches on the developmental characteristics of Red Sea pops. of *Daphne longispina* O. F. Müller, especially their variability cycles, and some phenomena of allometric growth in connection with their age variation and cyclic development as far

(*Continued on page 66 P&R*)



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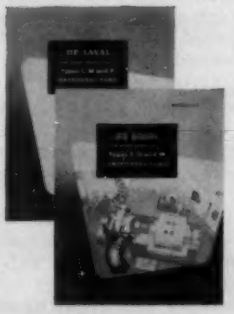

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(Continued from page 64 P&R)

as clarification of their propagation conditions are presented. In addn., quant. studies with object of investigating *Daphnia longispina* in relation to its position as a pop. element of crustacean plankton, pop. periodicity of this planktonic community throughout yr—and in comparison with earlier work—grade of stability in compn. of this assn. over period of 2 yr are described.—*PHEA*

The Planorbid Snails of the State of Ceara. O. FERREIRA BEZERRA. Rev. brasil. malariol. e doencas trop. (Rio de Janeiro), 7:3:351 ('55). Survey of 68 localities in 15 counties of Ceara (Braz.) revealed species *Tropicorbis stramineus, T. janeirensis, Gryaulus melleus, Drepanotrema cultratus, D. cimex,* and *D. anatinus.* 1st was most numerous (90% of all identified specimens), had widest distr. (all counties) and was only species found naturally infected by *Schistosoma mansoni* (up to 0.25%).—*PHEA*

BOILERS AND FEEDWATER

Methods of Analysis and Their Use in Solving Boiler Problems. T. SAMUEL. Bull. centre belge etude et document. eaux (Liege), 32:99 ('56). Author describes detn. in boiler water of sulfides, silica, ammonia, and amines. Effect of pH value on corrosion and scale formation, detn. of salinity of steam, use of reducing agents for removal of oxygen, and detn. of oxygen are discussed.—*WPA*

Rapid Methods of Boiler-Water Analysis. J. BANKS & J. ROBSON. Analyst (Br.), 83: 98 ('58). Following rapid methods are recommended for water anal. for boilers operating >400 lb/sq in. For Cl^- neutralize to pH 4.5 with 0.1 or 0.02*N* H_2SO_4, add HgO $\cdot Hg(CN)_2$, and titrate again with std. acid. For total acidity and PO_4^{---}, pass sample through cation-exchange column (Zeo-Karb 225 in H^+ form) and titrate with std. base to methyl red-methylene blue end point. Add $Ce(NO_3)_3$ soln. and titrate acid liberated equal to PO_4^{---}. Sulfate is found by difference. Up to 30 ppm SiO_2 have no effect. NO_3^- is counted as SO_4^{--} if present. Tannins must be removed by charcoal treatment, SO_3^{--} has only limited effects but is not usually present.—*CA*

International Conference on Hydrazine and Water Treatment. R. L. REES. Chem. & Ind. (London), 726 ('57). Author summarizes some of findings of Intern. Conf. on Hydrazine and Water Treatment, held at Bournemouth (Br.) in May '57 and discusses advantages of using hydrazine to treat boiler feedwater for removal of oxygen and control of corrosion.—*WPA*

Experimental Investigation of Hydrazine-Oxygen Reaction Rates in Boiler Feed Water. N. L. DICKINSON; D. N. FELGAR; & E. A. PIRSH. Proc. Am. Power Conf., 19:692 ('57). Reaction rate increases rather rapidly with temp. to extent that substantially O_2 can be completely removed at 400°F. with reasonable values of reaction times and N_2H_4 concn. Continuous anal. for H_2 and N_2 at boiler outlet proved to be extremely effective means for detecting N_2H_4 decompn., which is expressed as $2N_2H_4 = H_2 + N_2 + 2NH_3$.—*CA*

Water Treatment and the General Control of a High-Pressure Boiler, Especially in Connection with the Determination of Hydrogen in Live Steam. A. BERGER; J. PIROTTE; & L. BOVYN. Bull. centre belge etude et document. eaux (Liege), 3:140 ('57). Reactions between water or pure steam and Fe are: 250–550°F, $4H_2O + 3Fe \rightarrow Fe_3O_4 + 4H_2$ and <150°F, $2H^+ + Fe \rightarrow Fe^{++} + H_2$. 2nd reaction is pH-dependent and may be limited by pH increase. It is indirectly dependent on O content. It is suggested that pH control can be effected by addn. of various volatile amines, e.g., cyclohexylamine or morpholine. Also at 250-500°F pH control by addn. of K_3PO_4 is strongly advised. Corrosion of Fe can be detd. by detn. of H generated in boiler. App. is described for taking samples of gases dissolved in live steam. 2 different methods of anal. are applied. Spectrophotometric detn. of HCl after reaction of the H with NaClO under ultraviolet radiation and chromatographic detn. both have a sensitivity of about 0.1 γ H/l. Such detn. should generally be made. H should be kept below 0.5 γ/l.—*CA*

Purposes and Limitations of Hydrogen Determination in High-Pressure Industrial Boilers. E. ULRICH. Mitt. Ver. Grosskesselbesitzer (W. Ger.), 49:252 ('57). Under h.-p. operation, boiler iron is subject

(Continued on page 68 P&R)

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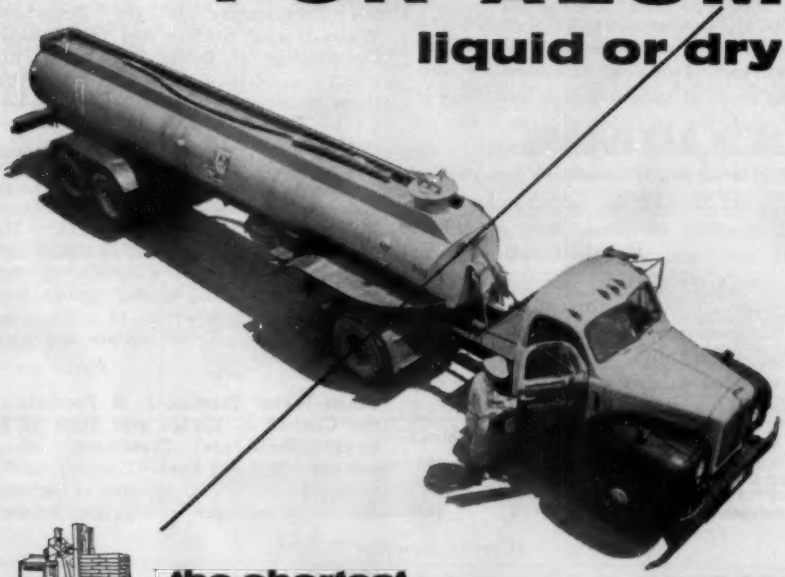

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(*Continued from page 66 P&R*)

to oxidizing attack, with release of H. Detn. of H is, therefore, useful in discovering corrosion and predicting boiler failure. Usual method of detg. H consists of sampling steam at various points, condensing it, and analyzing uncondensed gases. Eqs. of WAGNER'S theory (C.A., **30**:5165[8]) are useful in relating H concn. to formation of Fe_3O_4 and FeO, but are subject to limitation that sampling of steam, done at definite sites, gives avg. H concns. and may not necessarily reveal presence of point sites of corrosion. It is demonstrated that diffusion of H away from boiler interior, through boiler material, is of signif. in detns., except at very low H concns. Avg. range of H concn. in boilers is $(2.24\text{–}44.9) \times 10^{-9}$ g H/g H_2O. Data obtained in H detn. should be interpreted with caution, since both procedure and theoretical interpretation are not completely satisfactory.—*CA*

Relation Between the Scale Formation, the Temperature of the Zone-Limit Water-Heated Surface and the Chemical Composition of Boiler Water. G. BIANUCCI & L. GHIRINGHELLI. Bull. centre belge etude et document. eaux (Liege), **3**:157 ('57). To establish ratio CO_3/SO_4 in boiler scale it is necessary to det. soly. product of $CaCO_3$ and $CaSO_4$ under conditions existing in boiler. Soly. products of $CaSO_4$ and hydrolization consts. of reactions $CO_3^{--} + H_2O \rightleftharpoons HCO_3^- + OH^-$ and $HCO_3^- + H_2O \rightleftharpoons H_2CO_3 + OH^-$ are detd. by chem. anal. at 200–250°F. Ratio CO_3/SO_4 at these temps. is calcd. and plotted against temp. It is necessary, however, to exam. temp. gradient between heated surface and water. —*CA*

Boiler-Water Treatment: A Formula for the Control of Sludge and Scale in Internal (Carbonate) Treatment. W. F. GERARD. J. Inst. Fuel (London), **31**:139 ('58). Maint. of 200–300 ppm of carbonate alky. in boiler water, as suggested by GRAY

(*Continued on page 70 P&R*)

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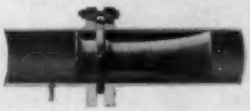
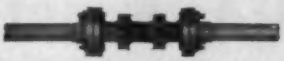
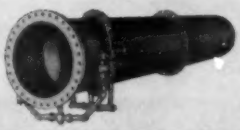
NORMAL WATER, AIR OR GAS FLOWS		TYPE TG—INSERT TUBES AND NOZZLES Withstand high pressures. Fit inside existing lines . . . permitting light construction. This, plus *short length*, cuts costs. BULLETIN 100
SMALL FLOWS OF WATER, GASES CORROSIVE FLUIDS		TYPE TF—MINIATURE VENTURI TUBES Machining to .0005" assures accuracy. Main diameters as low as ⅛"; throat diameters down to .1". Welded stainless steel models for high pressures. BROCHURE
NORMAL SEWAGE, SLUDGE, TRADE WASTES		TYPE VTJ—SINGLE TAP VENTURI TUBES Single taps at main and throat have bayonet-type valve for fast cleaning. Absence of pressure belts prevents clogging. Inspection opening at throat. BULLETIN 005
NORMAL SEWAGE, SLUDGE, TRADE WASTES		TYPE VS—FOUR TAP VENTURI TUBES Four cleaning valves at main and throat can be operated manually, by air, or hydraulically to keep piezometer holes clear for top accuracy. Two hand holes on each pressure belt and inspection opening at throat. BULLETIN 005
LOW-VELOCITY SEWAGE, HEAVY WASTES		TYPE VE—ELLIPTICAL VENTURI TUBES Developed specifically to accurately measure low-velocity sewage, sludge and heavy trade wastes—under low pressures. *Flat top* prevents air binding. *Flat bottom* is self-scouring. Inspection opening at throat. BROCHURE
LOW-HEAD SEWAGE, SLUDGE, TRADE WASTES		TYPE S—PARABOLIC FLUMES Full 20:1 range for open flows. Accuracy ±2%. Flanged, bell or spigot inlet for 6 to 36" lines. Integral sediment trap, piezometer reamer, gauge glass, direct-reading flow scale. BULLETIN 801

(*Continued from page 68 P&R*)

(C.A. **52**, 622*e*) is difficult owing to decompn. of Na_2CO_3 at boiler-water temps.; caustic cracking might result because of excessive NaOH. Increase in total solids content of boiler water would also cause large increase in blow-off and increase in CO_2 in steam would cause increased corrosion by condensate. Addn. of $MgSO_4$ and Na_2SO_4 to ingoing feedwater is apt to lead to heavier deposits in pipes, pumps, valves, etc. **Reply.** J. A. GRAY & M. S. TIMMS. *Ibid.*, 139.—Experience has shown that maint. of desired Na_2CO_3 concn. is not difficult, without development of undesired alky. Furthermore, addn. of $MgSO_4$ actually increases Na_2SO_4/NaOH ratio. Boiler blowdown is to remove suspended matter; with suggested treatment sludge is easily blown down by normal procedures. There is no reason to believe that small increase in CO_2 content of steam will have much effect on corrosion by condensate, as CO_2 is usually present. In practice, Na_2CO_3 soln. is not introduced with feedwater but is injected directly into boiler through separate, small feedline. Addn. of Mg salts to feedwater materially reduces $CaCO_3$ scaling in feedlines, economizers, etc., and is covered by Br. patent application.—*CA*

CANADIAN WATER SUPPLIES —GENERAL

Water Works Systems. Munic. Utilities Mag. (Toronto), **95**:8:112 ('57). Alphabetical list of water systems in Canada serving pops. greater than 1,000 is given. Data on sources of supply, type of pumps, nos. and type of res., methods of water purif., distr., consumption, numbers of meters used, and names of officials are given for each system. —*WPA*

Problems Involved in Developing Greater Vancouver's Capilano Water Supply. K. E. PATRICK. Munic. Utilities Mag. (Toronto), **95**:8:29 ('57). Water supply of Greater Vancouver dist. is obtained from Capilano and Seymour rivers and Coquitlam lake. Cleveland dam has been constructed across Capilano R. to form impounding res. Water from res. is treated by screening and chlorination; description of treatment plant is given. Problems caused by construction of dam included provision of adequate supply of water for fishlife below dam, effect of twice-yearly lake turnover on mineral content of water and increase in turbidity during storms and periods of high river flow. Capac. of pipe system from dam is 80 mgd. Lake is capable of supplying 200 mgd.—*WPA*

One of the West's Newest Water Supply and Treatment Plants. J. P. SMALLWOOD. Munic. Utilities Mag. (Toronto), **95**:2:15 ('57). New water treatment plant has been built at Red Deer, Alta., to increase existing supply by 3.6 mgd. Water is pumped from Red Deer R. to Infilco Accelators which replace old mixing, coagulation, and sedimentation tanks. Solns. of lime and soda ash are added in Accelators for softening water and alum soln. is added for coagulation. Part of floc produced is recirculated for seeding, excess being concd. and automatically dischgd. to river. Softened water is stabilized by addn. of compressed carbon dioxide gas, filtered through rapid sand filters, and stored in 200,000-gal tank. Flow throughout plant is automatically controlled by level of water in clear well beneath filters. Water is chlorinated to give residual concn. of 0.1–0.3 ppm in plant effluent. Increase in city's pop. and in water consumption between '40 and '53 is shown in graph.—*WPA*

Water Supply in Canada Taxes Engineers' Ingenuity. G. T. G. SCOTT. Munic. Utilities Mag. (Toronto), **94**:3:42 ('56). Author gives outline, using examples, to illustrate general problems which confront engineers in providing water supplies throughout Can. Author then explains necessity for storage of water in prairies and for development of underground water supplies. Future plans for Nfld. and southwestern Ont. are discussed.—*WPA*

(*Continued on page 72 P&R*)

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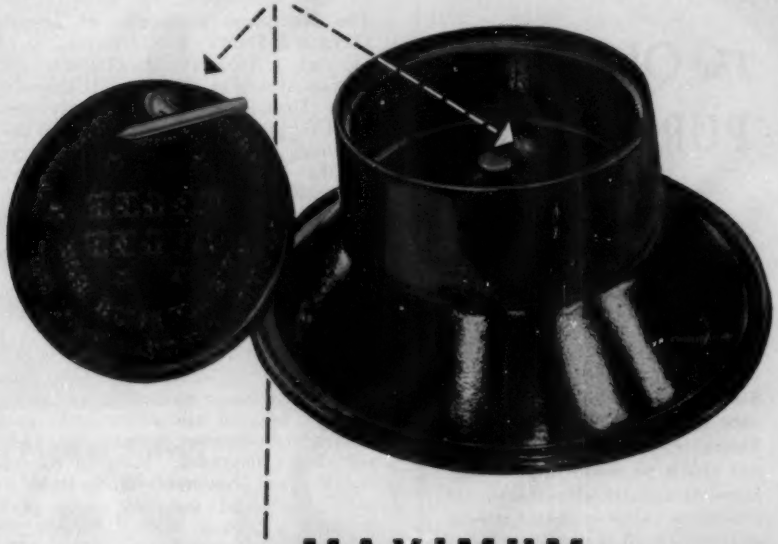

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(*Continued from page 70 P&R*)

DAMS AND RESERVOIRS

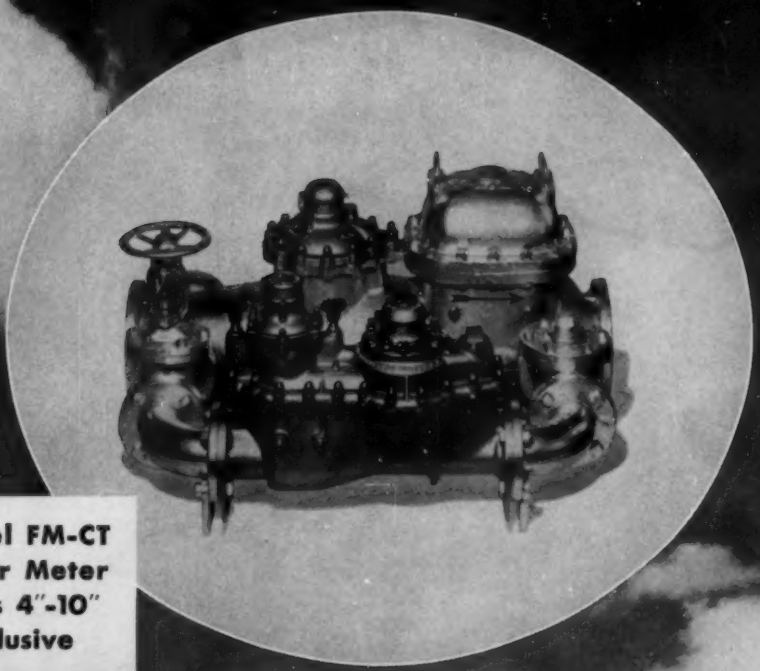
The Nocturnal Reduction of Dissolved Oxygen in Dams. B. S. NEWELL. E. African Agr. J. (Kenya), **23**:127 ('57). Investigation of dam on Jamal Walji Estate near Jinja (Uganda) shows that not only does diurnal fluctuation of O content occur due to alternation of photosynthesis and respiration, but that nocturnal cooling of surface water can produce overturn of water column, which denudes surface water of O.—*CA*

The Oxygen Content of the Water in Dams in Ankole, Uganda. F. R. FISH. E. African Agr. J. (Kenya), **20**:178 ('55). Presence of large nos. of dams in E. Afr. constructed primarily for storage of water, has led to considerable interest in cultivation of pond fish. Some dams support considerable pops. of fish without addn. of fertilizers, but stocking of dams with fish is not always successful. Many of conditions which affect growth of fish in dams have been investigated, including concn. of DO in dams in Ankole dist. of Uganda. Results of anals. made in Aug. '53 and Mar. '54 are given and discussed and importance of factors which affect concn. and distr. of DO are considered briefly.—*WPA*

Water Reservoir Evaporation Control. R. G. DRESSLER & A. G. JOHNSON. Chem. Eng. Progr., **54**:66 ('58). Review of evapn. theory in relation to large bodies of water. Savings of more than 20 bil gal of water daily in US are seen possible as result of new monomolecular-film techniques for cutting down evapn. from lakes and reservoirs. —*CA*

Processes in Natural and Artificial Lakes of Importance in the Construction and Operation of Impounding Reservoirs for Water Supply. J. GRIM. Gas- u. Wasserfach. (Munich), **98**:234, 277 ('57). Author describes processes taking place in natural lakes and differences between natural lakes and impounding reservoirs. Processes of aging and development and condition of oligotrophic, eutrophic, and polytrophic types of lakes, horizontal and vertical movement of water, and effects of wind and sun, and of poln. are discussed. Descriptions are then

(*Continued on page 76 P&R*)



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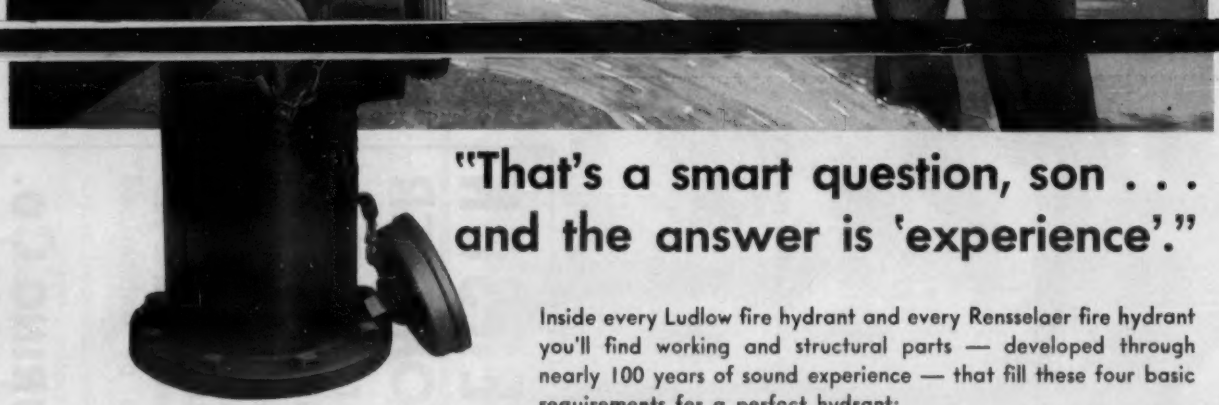
what's
inside
besides
water?"



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(*Continued from page 72 P&R*)

given of conditions in bodies of water during periods of summer stagnation, autumn circulation, winter stagnation, and spring circulation, and of influence and movements of influent streams during these periods. Factors affecting use of water of impounding reservoirs for supply are discussed, with special reference to choice of suitable depths of intake.—*WPA*

New Reservoirs Aid Industrial Expansion. A. R. MacPherson. Public Works, N.Y., **88**:4:103 ('57). 2 large reservoirs have been recently constructed at Tacoma, Wash., as final step in program for rebldg. and modernizing its water system. Tacoma now has 8 reservoirs in use, to serve pop. of 156,000, and over 300 industrial plants. Original wooden mains have been replaced with iron pipe. Green R. pipeline supplies most of city's water demands and is supplemented by numerous wells located in S. Tacoma area. Largest of 2 new reservoirs is situated 20 mi. E. of Tacoma, and has capac. of 100 mil gal. 2nd reservoir is at Tacoma and has capac. of 50 mil gal. Dam is being constructed on Green R. in order to control flooding.—*WPA*

Limitations on the Recreational Use of Domestic Water Reservoirs. C. E. Smith & B. S. Ongerth. Public Health Repts. (U.S.), **72**:499 ('57). In paper presented at Conf. on Recreational Use of Impounded Water, held in Richmond, Calif., '56, authors discussed practicability of using domestic water supply reservoirs for recreational purposes. If strict measures of control are not enforced, then water may become pold. and subsequently transmit disease.—*WPA*

Measurement of Sedimentation in TVA Reservoirs. E. H. McCain. Proc. ASCE, **83**:HY3:No. 1277 ('57). Author describes equip. and methods which are being used by TVA in current studies on sedimentation in 30 reservoirs in valley. Some of equip. is illustrated in photos.—*WPA*

(*Continued on page 78 P&R*)

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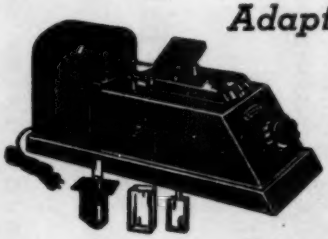

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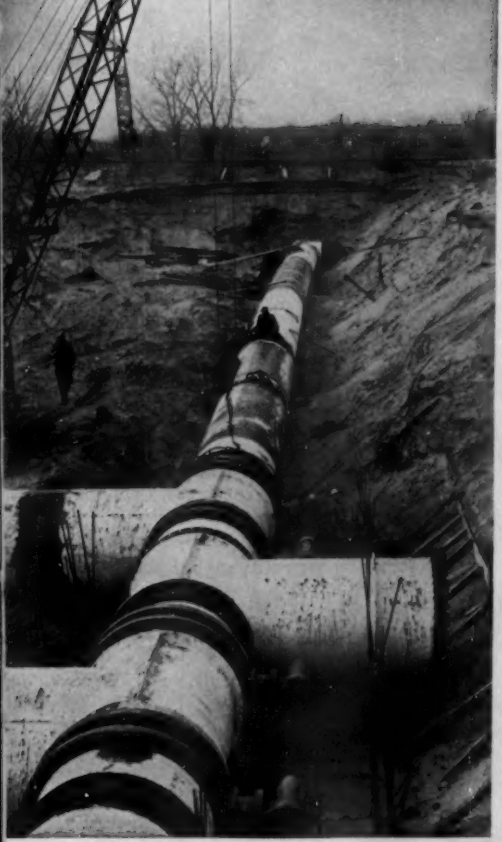

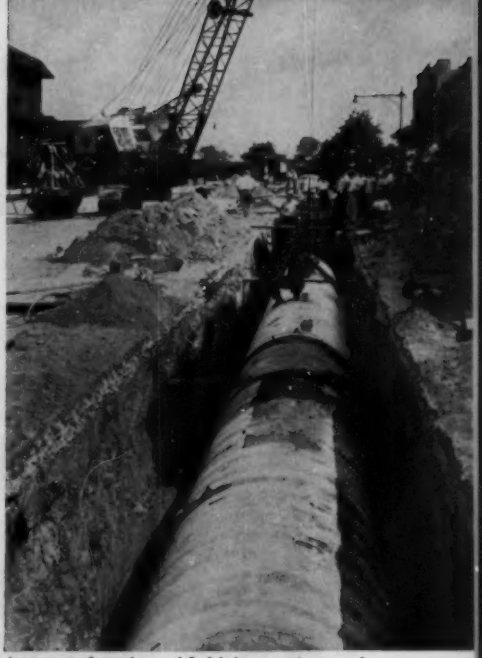

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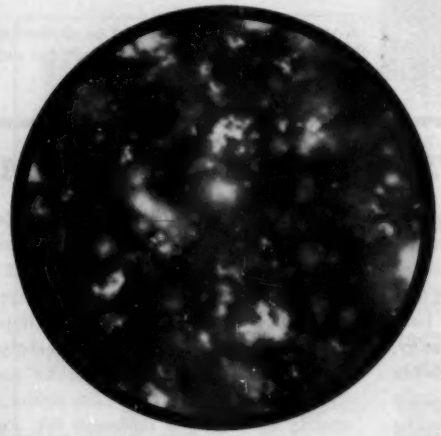
(*Continued from page 76 P&R*)

Shustoke and Bartley Reservoirs: Biology. R. C. WHITEHEAD. J. Instn. Water Engrs. (London), 11:289 ('57). In paper presented at meeting of Midland Sec. of Inst. Water Engrs., held in Jan. '55, author described study of algae in Shustoke and Bartley reservoirs of Birmingham Water Dept. (WPA, 22:473, '49) during period '46–'55. Weekly counts of blue-green algae and diatoms were made and results, which are shown in form of diagrams, are discussed. Presence of more than 500 cells of *Asterionella*/ml in Bartley R. water caused severe cloggings of rapid gravity filters. Examn. of samples from aqueduct which conveys water from Elan Valley reservoirs to Bartley and Frankley reservoirs, and of Frankley Res. water, showed almost complete absence of algal growth. It is suggested that presence of algae in Bartley, but not in Frankley Res., may be due to large area of comparatively shallow water in former, together with slight leakage of pold. water into this reservoir. Tables are given showing characteristics of Bartley and Frankley reservoirs, and anals. of water from Bartley and Shustoke reservoirs and an Elan Valley res. Biol. development of the Claerwen Res., which was constructed in Elan Valley in '51, was studied from '52 to '55 and compared with development of 2 other reservoirs in valley, which were built 50 yr earlier. All 3 were found to be extremely deficient in algal growth and chem. compn. of water in each was similar. It was considered that slight increase in nutrient might greatly increase growth of algae. Results of dosing Bartley and Shustoke reservoirs with copper sulfate are discussed and summarized in form of table. Doses of 0.3 ppm were not toxic to trout in latter res.—*WPA*

Two-Part Service Reservoir for Paignton and Brixham. STAFF ARTICLE. Surveyor (London), 116:911 ('57). Description of 2-part res. having total capac. of 2.5 mil gal (imperial) with dimensions of 255 × 114 ft

(*Continued on page 80 P&R*)



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(*Continued from page 78 P&R*)

in plan and roof supported by 65 precast concrete columns. Walls 18 ft 9 in. high above floor level were 10 ft 6 in. thick at base, reducing to 1 ft 6 in. at top, are of mass concrete of which unique feature is that inner 18 in. is of 1:2:4 mix, to which Colmanoid was added, remainder of wall 1:3:5 mix with no additive. 2 classes were poured simultaneously, being separated during pouring by sliding shutter. Feature of article is description of contractor's constr. methods since res. built on shale and slate side hill was required to be finished and ready for use in 7 mo. from acceptance of tender. Contractor's job was complicated because of his inability to use explosives in excavation because he was pouring concrete in structure during process of excavation. —*PHEA*

The Regime of Dissolved Gases and Hydrobiology of the Tzimlyansk Reservoir During the Period of the First Winter Stagnation (1952–1953). N. G. FESENKO, ET AL. Gidrokhim. Materialy (Moscow), **25**:98 ('55). Anoxic conditions are to be expected during first 2–3 yr of existence of res. owing to abundance of plant life which consumes most of O. Despite vigorous measures enough vegetation remained to serve as source of biogenic life. However, anoxic conditions did not materialize, amt. of O being high throughout observed period. This was due in part to intensive aeration and partly to qual. and quant. insignificance of zooplankton and benthos, resulting in insignificant consumption of O.—*CA*

Hydrochemical Nature of the Tzimlyansk Reservoir at the Initial Period of Its Exploitation. N. G. FESENKO. Gidrokhim. Materialy (Moscow), **25**:69 ('57). Res. supplies water to all Volga-Don installations and irrigs. arid areas of Rostov, Stalingrad, and Kamensk territories. It derives its water in main from R. Don. Mineralization is of variable nature, being at its peak during Spring. It contains high amt. of biogenic elements; P, total and ammoniacal N, nitrates, and nitrites were detd. Melting snow favors plankton life, resulting in oversatn. with O, appearance of carbonate, disappearance of CO_2, and increase of pH.—*CA*

Effects of Storage Impoundments on Water Quality. M. A. CHURCHILL. J. San. Eng. Div., Proc. Am. Soc. of Civil Engrs., **83**:1171 ('57). When water in free-flowing stream is impounded in large storage reservoir, changes in phys., bact., sanitary-chem., and mineral qual. of water are produced. While most of changes result in generally improved water qual., certain specific quals. and certain downstream water uses may be adversely affected. This paper presents and summarizes wide variety of observations made on reservoir waters in Tenn. Valley during past 20 yr. Facts obtained and general principles deduced therefrom should be helpful in forecasting changes in water qual. that are likely to occur in any proposed reservoir.—*PHEA*

Water Supplies in Impounding Reservoirs in Relation to the Amount of Snow. From Experiences in the Harz District. H. HAASE. Literaturber Wasser, Abwasser, Lutz & Boden (Ger.), **5**:192 ('56). Authors describe measurements of snow made in winter of '52–'53 and application of results to conditions in Sose impounding reservoir with special reference to flood protection, storage, and utilization of excess water. Earlier measurements in west Harz on evapn. and seepage from snow cover are to be extended.—*WPA*

Layering Phenomena and Currents in Artificial Reservoirs and Their Recognition in the Building and Operation of Impounding Reservoirs for Water Supply. H. G. HUMMEL. Gas- u. Wasserfach. (Ger.), **98**:238 ('57). Author discusses methods of preventing short-circuiting in impounding reservoirs and of observing and controlling condition of water drawn for supply.—*WPA*

Evaporation Losses and Control. U. STEPHENS. Pub. Wks., **88**:1:138 ('57). In paper presented by author at Second Annual Water Conf., Tex., he deals with water losses from reservoirs and methods of controlling these losses. Losses from Ft. Worth water supply, which is stored in 3 reservoirs, amtd. to 17,820 acre-ft during Jul. and Aug. '56 as result of evapn., transpiration, transportation, and seepage. Recommendations are made for control of these factors and several conferences have been held in at-

(*Continued on page 82 P&R*)

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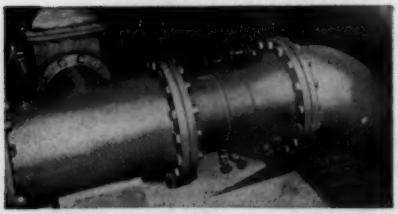

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(*Continued from page 80 P&R*)

tempt to reduce water losses. Research is in progress and use of surface film of hexadecanol is reported to save up to 43% of evapn. loss. Summary of results accomplished is given.—*WPA*

Sand-Built Reservoirs Lined with Asphalt. Surveyor (London), 116:751 ('57). 2 further asphalt-lined reservoirs have been built for Messrs. John Summers & Sons, Ltd., Dee-side steel-making concern, at Shotton, near Chester. Reservoir built in '53 for this co. was first in Br. to be made with impervious lining of hot asphalt. 1st reservoir is still in excellent condition after 4 yr and no expenditure has yet been incurred on maint. Each of 2 new reservoirs covers area of nearly 3 acres and has capac. of approx. 7 mil gal, with max. depth of 13 ft. Embankments were constructed of sand placed by hydraulic-fill method. Method of placement of sand which is pumped from borrow pit in adjacent marshes is described. Asphalt lining consisted of base course laid and rolled to min. consolidated thickness of 2 in., followed by layer of sand carpet asphalt with min. consolidated thickness of 1 in. Base course asphalt was special mix contg. 55% limestone aggregate, designed to give max. strength and impermeability, and sand carpet was in accordance with B.S.S. 594, Table 12, Schedule 7, with bitumen content of 12½%. Rolling was carried out with 6-ton roller on base and with 2½-ton roller on embankments. Special precautions were taken to provide good seal between asphalt lining and inlet and outlet flumes. Nearly 5,000 tons of asphalt were used in lining of 2 reservoirs, and this part of work took just over 5 mo. to complete.—*PHEA*

HYDRAULICS

Measuring of Turbidity of Water in Mains and Flushing of Mains. W. KAUFFMANN. Water (The Hague), 39:185 ('55). Author discusses desirability of rapid method of detg. turbidity of water and describes app. for this detn. App. is based on interference to passage of light rays by turbidity in water.—*WPA*

(*Continued on page 84 P&R*)

MORE WATER FOR SPRINGFIELD

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Springfield, Ohio, is joining hundreds of other cities using Armco Welded Steel Pipe to meet the increasing demand for water. At the new Springfield water works, Armco Pipe in 24- to 36-inch diameters was installed for influent, filter, wash, waste, and discharge lines.

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(*Continued from page 82 P&R*)

The Problem of the Vertical Rate Curve in Natural Streams. S. KOLUPAILA. Osterr. Wasserwirtsch., **9**:13 ('57). Author discusses and criticizes suggestions of M. Lippke on shape of curves used for calcn. of vertical flows.—*WPA*

Estimation of the Rate of Suspended Settleable Particles From That of the Water. H. P. SCHMITZ. Acta Hydrophys., **4**:93 ('57). From settling rate of suspended particles, possible order of difference in speed between these and surrounding water is estd. and discussed.—*WPA*

Evaluating Effects of Land Use Changes on Sediment Load. A. J. COOPER & W. M. SNYDER. Proc. ASCE, **82**:HY1, No. 883. Anal. method used to evaluate, by application of statistical methods of multiple regression, effects of density of covering growths and land use in watersheds on suspended sediment characteristics is described. Method was applied to data relating to rainfall, runoff, and sediment load in White Hollow and Chestuee Creek watersheds of TVA, US, in investigations covering periods of 18 and 10 yr respectively, during which time considerable improvements were carried out as regards vegetal cover and land use. Relevant figs. and tables are appended.—*WPA*

Transport of Settleable Material in Straight Channels as a Marginal Value Problem. H. FORTAK. Acta Hydrophys., **4**:26 ('57). Green function is developed for behavior of settleable matter in straight channels in general marginal conditions of channel walls and surface.—*WPA*

Flow Measurements From Bridges. H. GILS. Deut. Gewasserkundl. Mitt. (Ger.), **1**:12 ('57). Detailed illustrated description is given of travelling carrier which can be fixed to railings of bridge and from which current meter can be suspended. Method of using app., by which measurements can be made at times of flood when normal measuring places may be inaccessible, is described. —*WPA*

Two-Dimensional Ground Water Flow Through a Bank With Vertical Faces. T. G. CHAPMAN. Geotechnique (London), **7**:35 ('57). Eqs. derived by M. Muskat have been used to calc. height of seepage surface when ground water flows through bank with vertical faces. Results are shown in form of graphs and are compared with those obtained by other investigators, based on different theories. Critical depth theory for ground water flow is discussed and simple formula for detn. of shape of free surface is given.—*WPA*

Backwater Curves in Trapezoidal Channels. A. R. OLIVER. Commonwealth Engr. (Austral.), **45**:3:53 ('57). 2 nomograms for use in backwater curve calcns. and for checking flows in natural watercourse have been devised. Nomograms are based on trapezoidal shape, which was chosen because of its wide application in artificial channels and its approximation to number of natural stream beds. Methods of use of nomograms and their application are outlined.—*WPA*

POLLUTION CONTROL

Progress in Air and Stream Pollution Control Nation Wide. K. S. WATSON. Ind. Wastes, **1**:191 ('56). Progress in air and water poln. control are considered together since they are closely related one to other. In-plant control is sound and most economical answer to poln. problem. Water poln. control laws are now in effect in 39 states, trend is toward state control commn. and 19 states use this device. There are now 5 interstate compacts, Ohio R. Valley Water Sanitation Commn. covers greatest area and 8 signatory states and serves 17 million people. Treatment facilities are in operation or soon to be for 81% of pop. of Ohio basin. Public Law 845 set up USPHS as agency for water poln. control at Federal level. Completion of R. A. Taft San. Eng. Center, signal development as world's foremost research center on water and air poln. control. Industry has pooled its efforts on generic basis in seeking soln. to poln. problems. Over $3 million was spent in '55 on industrial waste problems by industry and govt. USPHS studies show that

(*Continued on page 86 P&R*)

Aerial view of the R. C. Harris Plant of The Municipality of Metropolitan Toronto; R. L. Clark—Commissioner of Works. Photograph was taken during construction of plant's additional facilities.

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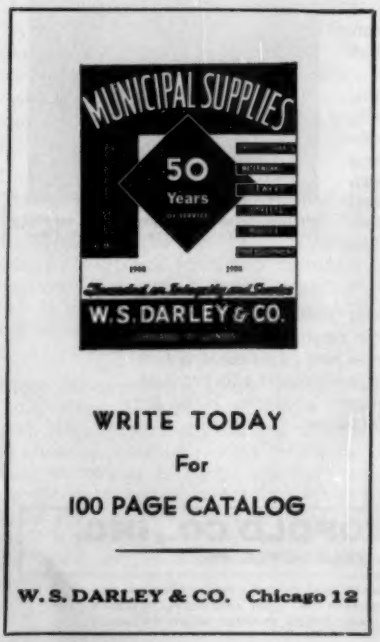
(*Continued from page 84 P&R*)

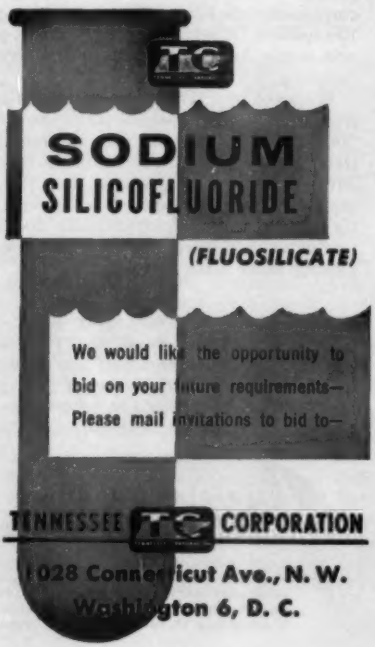
addnl. 2,508 industrial waste-treatment plants are needed and at least 3,618 plants for municipal treatment serving 24 million people. Alleghany County San. Authority $100 million project will serve 68 municipalities and 20 industries.—*PHEA*

Universal Factors in Aerobic Biological Purification. M. B. ETTINGER. Sewage and Ind. Wastes, **30**:14 ('58). Recurrent patterns of oxidative food utilization by microorganisms and destruction of cellular material by oxidation in unfed cultures is discussed. It was pointed out that there is similarity in these phenomena in natural stream purif. and in activated-sludge and trickling-filter processes. Universal effect of nutritional deficiencies on growth characteristics is reviewed, and effect of these deficiencies on oxidation and growth of microorganisms is considered. Sewage treatment plant and its operation are described. It was mentioned that sewage treatment operation entails daily cycle and that there is excess oxidation capac. at night because of reduced load. Cyclically illuminated system is illustrated. This system is assumed to contain mixed biol. pop. which includes certain species of algae capable of growing in system. Algal photosynthesis was analyzed in its relative effect on oxidative purif. processes.—*CA*

Court Decisions and Statutory Provisions in Water Pollution Control Law. W. H. RESH. Sewage and Ind. Wastes, **28**:211 ('56). Judgments through yr are cited which indicate responsibility of regulatory agencies, municipalities, and individuals in field of water poln. abatement. It was decided that state may exercise police power to cause sewage to be purified before dischg. into stream, or it may prohibit use of stream

(*Continued on page 88 P&R*)





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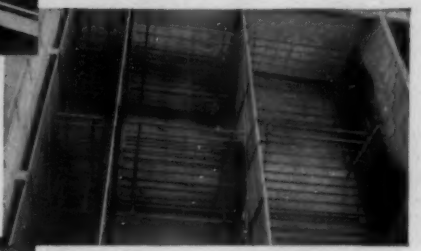

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(Continued from page 86 P&R)

for such purpose even after modern treatment. In this field legislative detn. is binding on courts. Injunctive relief and awards for damages must be weighed in view of individual injury and harm to community. Details of cases are reported in which municipalities operating sewage treatment plants were forced to compensate individuals for temporary or permanent damage to property. In other actions no judgment was held against governing body. Cases in Wis. are given regarding decisions regarding industrial waste or sewage poln. Decisions covering obligation of municipality to treat industrial wastes are given. 2 cases of joint poln. are discussed and 2 different decisions are stated. Proof of and degree of damage are illustrated by record. Jurisdiction of local courts, cities, and state agencies is shown in 3 cases. Discussion of all these actions, and others in Ill. is given by C. W. KLASSEN.—*PHEA*

The Water Pollution Research Laboratory and Its Work. B. A. SOUTHGATE. Roy. Soc. Promotion Health J. (London), **76**:357 ('56). Work at new lab. at Stevenage is outlined. Staff edits WPA as essential part of their work. Since '27 lab. has been active in estuarine investigations on the Tees, Mersey, and Thames (rivers), but in Jun. '55 they officially opened their new bldg. Phys. facilities of lab. are described and major areas of research discussed on industrial effluents, effects of poln. on fish, automatic instruments, and radioactive poln. —*PHEA*

Purification of Retting Waters. L. GHYSSAERT. Bull. centre belge etude et document. eaux (Liege), **3**:186 ('57). After showing necessity of recycling wastes from flax retting, purif. by aerated sludge system is described. Sufficient aeration permits decrease of concn. of volatile fatty acids of 88% in 6.8 hr. In another installation similar results are obtained and decrease to 60% was made possible. Microorganisms live in suspension here and are not to be found in sludge. BOD no. in this case was reduced from 8.25 to 2.03 g/l O. In 3rd installation reduction of BOD no. from 4.84 to 1.9 g/l O was observed. pH was increased from 5.2 and 4.49 to 6.25 and 6.44, resp.—*CA*

Tests on Purification of Retting Waste Water by Means of Activated Sludge. L. GHYSSAERT & L. WAUTERS. Bull. centre belge etude et document. eaux (Liege), **4**: 242 ('57). Because of high Fe content of Belg. flax, removal of Fe from retting water by simple aeration is not effective. Increase of vol. of activated sludge by inoculation with selected microorganisms was ineffective, and electrolysis reduced Fe sufficiently in only few cases. Only effective procedure was aeration in presence of yeast, followed by flocculation with lime. Volatile acids were removed with "dispersed growth aeration," activated sludge, or by aeration in presence of yeast. Iron bacteria were ineffective in "dispersed growth" procedure. —*CA*

The Problems of River Pollution in Industrial Areas. L. KLEIN. Roy. Soc. Promotion Health J. (London), **76**:348, 363 ('56). Provisions of Rivers (Prevention of Poln.) Act, '51, are outlined. This law replaced early River Poln. Prevention Act, 1876. Problem of overloading at sewage works is acute due to addnl. load of industrial wastes and deferred constr. Many plants cannot meet effluent stds. of 20 ppm BOD and 30 ppm suspended solids. Difficulties of River Board with industrial wastes are discussed from following points of view: (1) discharge of trade wastes to local sewers and necessity of balancing flow and pretreatments; (2) treatment in special plants of some wastes; (3) wastes that are difficult to treat, such as gas liquor; (4) peculiar characteristics of rivers that are very short and receive waste along their total length; and (5) poln. by tip (dump) drainage of both municipal refuse tips and sludges and other solid trade wastes. Paper is followed by discussion of those in attendance at Health Cong. at Blackpool (Br.). —*PHEA*

Computation of Pollution in the Yaquina River Estuary. W. V. BURT & L. D. MARRIAGE. Sewage and Ind. Wastes, **29**: 1385 ('57). Proposal to construct pulp mill on Yaquina R. at Toledo, Ore., and to dischg. mill wastes into river were motivating factors for study to det. what possible distr. of poln. in affected waters might be. Salin-

(Continued on page 90 P&R)

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(*Continued from page 88 P&R*)

ity observations were made during low flow and high flow periods from ocean to point 20 mi upstream. Data are presented showing cross-sectional areas and avg. salinities for each mi upstream to limit of salt-water intrusion. Graphs show expected distr. of poln. for summer and winter conditions. Results of study are of interest in that they may be used as guide for future poln. studies in numerous W. Coast tidal estuaries which are similar to Yaquina R. estuary.—*PHEA*

SWIMMING POOLS

Control of Algae in Swimming Pools. C. M. PALMER. J. Am. Med. Assn., **162**: 938 ('56). Effectiveness of algicides depends upon concn., method of application, and kinds of algae present. Copper sulfate is commonly used. If algae are planktonic, copper sulfate can be placed in burlap bag which is then dragged through water just below surface until algicide is dissolved. Approx. 2 ppm of commercial grade copper sulfate is sufficient to control common planktonic algae found in many swimming pools. By applying 2.5 oz. by wt. of copper sulfate for every 10,000 gal of water in pool, approx. that concn. is obtained. Treatment is most effective if applied before algae become so abundant as to be visible. Where water in pool is changed each wk, 1 treatment each time pool is filled would be adequate. For control of algae attached to walls, treatment is applied when pool is drained. As much of growth as possible is scrubbed off, and then walls are sprayed with 5% soln. of commercial copper sulfate. Active ingredients in other algicides include such chems. as chlorine, 2,3 dichloronaphthoquinone, quaternary ammonium compds., rosin amines, colloidal silver, and 3-(p-chlorophenol)-1, 1-dimethylurea. Information available from local health authorities should be useful in detg. kind of algicide and treatment permitted or recommended for swimming pools in any 1 locality.—*PHEA*

Swimming Pool Chemicals and Possible Resultant Problems. T. J. LEDGETT; E. J. STENSBOL; & B. S. WEINTRAUB. Sanitarian, **19**:9 ('56). Information of value to sanitarians and swimming pool operators is contained in this article. Authors first review basic chemistry of pH, hypochlorites, chlo-

(*Continued on page 92 P&R*)

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(*Continued from page 90 P&R*)

rine gas, and other chems. used to service swimming pools. Discussed in detail are following problems: eye smarting and green water, algae control, and turbidity. Eye irritation in bathers may be caused by any of following conditions existing in swimming pool water, namely: acid condition (pH below 7.0), use of hypochlorites for chlorination, abrasive action of water on eye surface, and presence of body wastes. Of various methods suggested for algae control, authors recommend daily treatment of pool water with chlorine. Superchlorination (chlorine residual of 10 ppm) for 1 day is best done while pool is not in use. This procedure will kill most algae. Some of causes of water turbidity in swimming pools are: faulty equip., improper chem. treatment of water, improper operation of filters, and overcrowding of swimming pool. According to authors, key factors in swimming pool maintenance are daily testing of water for pH and residual chlorine along with keeping of accurate records of these tests. Also considered important is regular inspection of water filter operation. Desired stds. to maintain are pH of 7.2 and chlorine residual of between 0.3 0.5 ppm.—*PHEA*

Estimation of Required Chlorine Dosages. ANON. Beach & Pool, **29**:17, 28, 31 ('55). Some of factors influencing rate of chlorine consumption of swimming pool are algae growths, nature of surrounding terrain, airborne contamn., sunlight, and bathing load. Effect of these various factors on chlorine losses is discussed. Table is presented showing approx. normal daily chlorine requirements per 50,000 gal pool capac.—*PHEA*

A Study of Bacterial Flora in Swimming Pool Water Treated With High-Free Residual Chlorine. E. D. ROBINTON; E. W. MOOD; & L. R. ELLIOT. Am. J. Pub. Health, **47**:1101 ('57). In continuation of investigations on outdoor and indoor swimming pool treated with high-free residual chlorination (see WPA, **47**:No. 1998, '54), further studies have been carried out on 2 indoor pools, one using marginal chlorination

(*Continued on page 94 P&R*)

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(*Continued from page 92 P&R*)

and other using intermittent applications of hypochlorite resulting in low values of marginal residual chlorine. Methods of bact. examn. used are described in detail. Results, given in tables, showed that high-free residual chlorination gives water of satisfactory bact. qual., and only pool receiving intermittent doses of hypochlorite contained large nos. of bacteria. In other pools, coliform organisms and enterococci were consistently absent in samples up to 200 ml. When concn. of free residual chlorine was 1 ppm or more, not more than 22 bact. colonies/100 ml were found on membrane filter. Organisms which survive high-free residual chlorination are those of genera *Bacillus* and *Micrococcus*, predominant organism being *Micrococcus epidermidis*, normal skin parasite. Nos. of bacteria which survived high-free residual chlorination did not appear to be related to no. of swimmers using pool. —*WPA*

Swimming Pool Operation. O. O. Olson. Offic. Bull. N. D. Water Works Conf., **25**: 3:20 ('57). Author stresses importance of correct design and operation of swimming pools. Methods of treating water are described briefly.—*WPA*

Surface Film on Swimming Pools. C. R. Amies. Can. J. Public Health (Toronto), **47**:93 ('56). In swimming pool oral and nasal secretions of bathers spread over surface are not dispersed in main body of water. Fatty substances derived from skin and hair also accumulate at surface and thereby contribute to formation of highly variegated and constantly changing surface film. Bacteria contained in these secretions remain in surface film and are thus protected from action of chlorine present in water below. Methods of removing surface film for quant. anal. are described. Calcium alginate gauze, commercially available fabric which dissolves in sodium phosphate solution, is used for this purpose. Results of study extending over 2 summer seasons are presented. These provide exptl. evidence in support of statements made above. Importance of swimming pools in spread of bact. and viral diseases is emphasized. Routine testing of swimming pool water should include a bact. examn. of surface film. Some practical suggestions regarding periodic removal of surface film are offered.—*PHEA*

TREATMENT—GENERAL

Physico-Chemical Studies of the Process of Treating Water With Activated Silica Gel. L. A. Kul'skii; M. A. Shevchenko; & G. Y. Turchinovich. Ukrain. Khim. Zhur. (Kiev), **23**:400 ('57). Presence of activated silicic acid does not alter rate of coagulation and settling of flocs formed in purifying H_2O with $Al_2(SO_4)_3$, no matter what proportions of $Ca(HCO_3)_2$, $CaSO_4$, and $CaCl_2$, or $NaHCO_3$, Na_2SO_4, and MaCl present. But, when FCl_3 is used, date is faster and shape of isochronous lines on triangular plot is altered. Viscosity of coagulating solns. was studied during course of coagulation. If $FeCl_3$ is used viscosity is not as great nor does addn. of SiO_2 increase it as much (especially for Na salt solns.) as when $Al_2(SO_4)_3$ is used.—*PHEA*

Development in the Treatment and Disposal of Sewage in Austria. J. E. Seidling. Institute Sewage Purif., J. Proc., Part 3:221 ('55). Austria is mountainous country located in central Europe. Main river, Danube, has mean flow of 2,000 cu m/sec (70,000 cfs) near Vienna. Country has Federal Water Right Law which aims not only at preventing deterioration of present status of surface waters, but also abolishing presently existing abuses. There are few secondary treatment plants; most of them are trickling filters. Requirements for plant effluent are minimal; no DO content is necessary and settleable solids must not exceed 0.5 cc/l. Capital costs of treatment works are financed by Provincial and Federal governments to level of 40–80%.—*PHEA*

Planning Can Reduce Waste Treatment Costs. F. L. Neff. Plating, **43**:1008 ('56). Factors affecting choice of treatment scheme in applying alk. chlorination method.—*PHEA*

Treatment Plants and Industry. E. Barocka. Gesundh. Ing. (Munich), **76**:109 ('55). Author describes difficulties now facing industry in disposal of waste waters with increasing demand for water, increasing poln., and decrease in possibility of selecting sites where sufficient suitable water is available for supply and waste waters can

(*Continued on page 96 P&R*)

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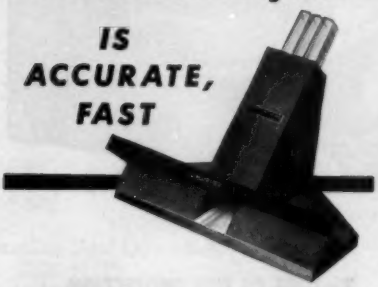

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(*Continued from page 94 P&R*)

be dischgd. He then discusses financing of treatment plants and, methods of planning by which costs can be reduced.—*PHEA*

The Study of Water Treatment. R. LEVIEL. L'Eau (Paris), 43:147 ('56). Use of certain lab. techniques, applicable in field to serve as basis for water treatment installations and their placement are considered. Points studied are, in particular: flocculation of water, speed of decantation, and qual. of sludge, sand filtration, and proposals for some new techniques. It is indicated, where possible, that with use of rapid and simple techniques efficient industrial treatments can be effected.—*PHEA*

Synthetic Detergents in Water and Sewage. O. J. SCHMIDT. Public Works, N.Y., 88:4:130, 189 ('57). Author reviews work which has been carried out on effect of synthetic detergents on sewage treatment and water treatment.—*WPA*

Synthetic Detergents and the Treatment of Water and Sewage. B. A. SOUTHGATE. Nature (London), 178:118 ('56). Since '49 there has been a 3-fold increase in sales of synthetic detergent mixts. in Br., majority of which contain anionic surface active constituent of alkyl aryl sulfonate type. Dischg. of most of these synthetic detergents to sewage treatment plants has been suspected of being cause of some difficulties. Part of surface-active agent passes unchanged through plant and is discharged to river. Presence of surface-active agent in raw water supplies has caused some concern. Author points to some differences of opinion between views expressed by Minister of Housing and Local Govt. in recent report on conditions in Br. and report issued by the Assn. of Soap & Glycerine Producers reporting their observations on detergent problem in US. Author suggests that mfrs. of synthetic detergents should investigate possibility of producing efficient washing products based on materials which can be readily oxidized by sewage treatment processes. Most of problems now presented by synthetic detergents would thus be eliminated.—*PHEA*

(*Continued on page 98 P&R*)

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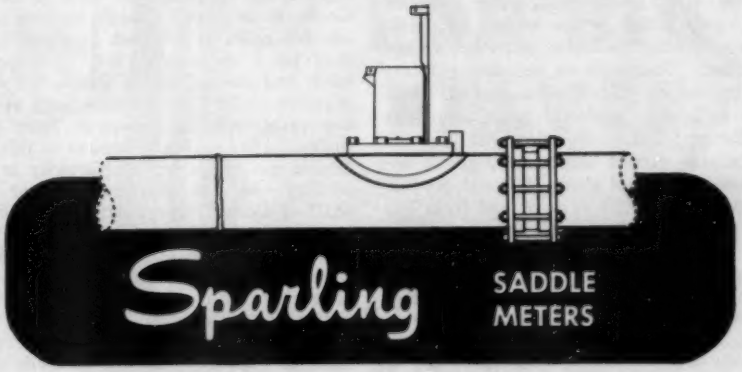

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(*Continued from page 96 P&R*)

Condition and Direction of Development of Treatment of Sewage With Special Reference to Industrial Waste Waters. W. HUSMANN. Schweiz. Bauztg. (Zurich), 73:No. 4 & 6 ('55). Author emphasizes necessity for careful choice of sites for industrial works with high water demands and highly concd. waste waters. Experiences with waste waters of yeast factory are described. Treatment on percolating filters and by evapn. proved unsuccessful; treatment in sewage works of large town was satisfactory; 2-stage digestion with gas collection also proved satisfactory, giving reduction in BOD of about 75% and producing daily about 650 cu m of gas from 180 cu m of waste waters. Waste waters from petroleum refinery were collected in tank holding 1 day's dischg. and were aerated, thus removing 50% of impurities before treatment in multiple-stage activated-sludge plant. With regard to waste waters from pickling of iron, author recommends use of electrolytic processes and mechanical burning-off in place of acid pickling; neutralization of acid pickling wastes with lime is permissible but costly. Vol., temp., cond., and reaction of waste waters should be continuously recorded.—*PHEA*

The Chemist and the Public Health Engineer in Relation to Water Treatment and Examination. W. G. CAREY. Water and Water Eng. (London), 61:248 ('57). Paper presented at joint meeting of Inst. of Pub. Health Engrs. and Soc. for Water Treatment and Examn., May '57. As water resources become depleted and poln. increases, need for adequate anal. of water becomes increasingly important. Author discusses methods of bact. and chem. anal., indicating types of organisms and chem. ions to which particular attention should be paid. —*WPA*

Treatment and Disposal of Liquid Wastes From Lac Industry. G. K. SETH; S. DE BHASKARAN; & T. R. BHASKARAN. Indian J. Med. Research (India), 43:3:539 ('55). In India approx. 334,000 gal of waste liquid per day result from manufacture of 167 tons of lac (about 60% of world's supply). These waste waters contain protein, sugar, fats, and inorg. salts. They are colored and have objectionable odor. Their content of suspended solids may be over 26,000 ppm and their BOD may be 20,000 ppm. Expts. made to det. best way of disposing of these waste waters are described. Content of solids is too high and pH value is too low for liq. to be treated directly by biol. methods, but addn. of 500 ppm lime and settlement for 1 hr removes 96% of suspended solids and about 79% of BOD; pH value is raised to 7.2. By-products, such as wax and resin, can be recovered from pptd. sludge. After prelim. treatment in this way effluent can be treated satisfactorily in percolating filters to give final effluent with BOD of about 150 ppm. If part of effluent is recirculated effluent with an avg. BOD of 80 ppm can be obtained. Alternatively, intermittent sand filtration of lime-treated effluent removes most of putrescible org. matter and gives clear, sparkling liq. with BOD of 50–100 ppm. Considerable purif. could be effected by storage of crude waste water in ponds; after 25 days suspended solids were about 600 ppm and BOD about 2,000 ppm.—*PHEA*

The Operation of Water Treatment Plants. C. H. BILLINGS. Publ. Wks., N.Y., 88:5:121, 150, 166 ('57). To provide basic information on water treatment and to assist training of students, author deals with various aspects of treatment of water, including phys., chem., and bact., methods of anal., design of plant, treatment by screening, coagulation, filtration, softening, disinfection, and fluoridation, identification and control of algae, and control of tastes and odors.—*WPA*

Fargo Water Treatment Process. H. H. BEHLMER. Off. Bull., N.Dak. Water Works Conf., 24:3, 5, 9 ('56). Water obtained from Red R. is treated at Fargo water treatment plant, N.Dak., by means of cold lime-soda softening process. Treatment consists of chlorination, coagulation with alum, and addn. of activated carbon to control taste and odor. Softening takes place in tanks of sludge-blanket type and any excess lime is pptd. by means of carbon dioxide. Water then undergoes sedimentation, chlorination, fluoridation, filtration, and clarification.—*WPA*

(*Continued on page 100 P&R*)

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Water Treatment Plant of the Town of Teheran, Iran. Tech. l'eau (Brussels), 10: 114:42 ('56). Water works of Teheran, Iran, have capac. of 225,000 cu m/day. Raw water is taken from Karaj R. Treatment consists of coagulation with ferric chloride, sedimentation, rapid sand filtration, and chlorination. There are 6 sedimentation tanks of Accelerator type and 40 filters of surface area 48 sq m.—*WPA*

Report on Operation of the Santa Rosa, California, Sewage Treatment Plant for the Initial Four-Year Period, July 1952–June 1956. M. B. McKinnie. Sewage and Ind. Wastes, 29:1309 ('57). New 5-mgd sewage treatment plant of Santa Rosa, Calif., was placed in operation on Jul. 2, '52. Plant provides preaeration, primary clarification, high-rate filtration, secondary clarification, and 14 days of detention in 2 stabilization ponds normally operated in series. Sludge from clarifier is digested in heated, covered digesters and dried on sand beds. Mechanically cleaned bar screen has been continuous source of trouble, ranging all way from broken shear pin to split drop plate. Hammer shafts on shedder must be shifted regularly to keep replacement period up to 1 yr; during 1st yr these shafts had to be replaced 4 times. Sludge pump controls failed to operate several times during 1st yr. This was found to be due to fluctuations in plant air supply. Small separate air supply corrected problem. Stabilization ponds have functioned satisfactorily except in Spring when algae disappeared for short time. Only difficulty with digester operation has been clogging of sludge circulation pumps with hair. Total cost of operation varied from $24.06 to $39.09/mil gal.—*PHEA*

Treatment of Waste Water from Breweries and Bakers' Yeast Plants. T. Wolski. Prace Inst. i Lab. Badawczych Przemyslu Rolnego i Spozywczego (Warsaw), 6:2:54 ('56). Lab. and pilot plant expts. showed that best purif. of waste water was obtained through 1- or 2-step CH_4 fermentation. B.O.D. was reduced in this way by 70–90%.—*CA*

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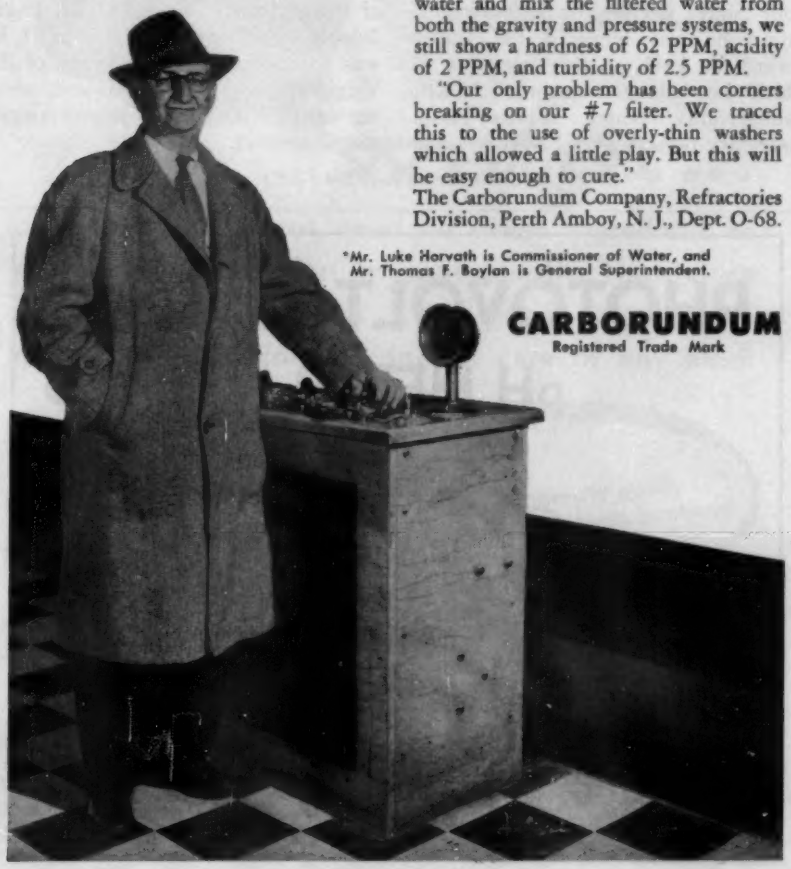

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(Continued from page 50 P&R)

Ivan M. Glace, consulting engineer, Harrisburg, Pa., died Sep. 6, 1958, at the age of 71. Born in Millersburg, Pa., in 1886, he attended Johns Hopkins University. In 1907 he joined the Engineering Bureau of the Pennsylvania Dept. of Health, where he remained until 1935. In that year he founded the consulting firm of I. M. Glace & Assocs. (later Glace & Glace), serving as president until his retirement in 1957.

A Life Member of AWWA (joined in 1921), Mr. Glace served as chairman of and director from the former Four States Section, on whose nomination he was tendered the Fuller Award in 1941. Other societies to which he belonged include ASCE, Pennsylvania Water Works Assn. (secretary-treasurer), FSIWA, and Pennsylvania Society of Professional Engineers.

Levi Larndon Hedgepeth, supervising engineer, American Cyanamid Co., New York, and adjunct professor in sanitary engineering at Rutgers University, New Brunswick, N.J., died Sep. 3, 1958, at his home in Bound Brook, N.J. He was 59. A graduate of North Carolina State College (1925), he took a position as chemist for the North Carolina Board of Health. In the early 1930's he became manager of the Technical Service Dept. of Pennsylvania Salt Mfg. Co., Philadelphia. Following World War II, he was named executive secretary of the Virginia Water Control Board, serving until 1949, when he joined American Cyanamid.

(Continued on page 104 P&R)

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(*Continued from page 102 P&R*)

An AWWA member since 1929, he received the Fuller Award in 1944, on nomination by the former Four States Section, for contributions in the fields of water treatment and advancement of operating safety. He was active on numerous AWWA committees, including Specifications for Liquid Chlorine (chairman), Joint Committee on Chlorine Supplies, Artificial Ground Water Recharge, and Industrial Water Use.

Henry W. Taylor, consulting engineer, Freeport, N.Y., died Jul. 14, 1958, at the age of 78. A specialist in waste treatment plants and sewer systems, he was the inventor of a method of treating tannery wastes. Mr. Taylor had been an AWWA member since 1948.

Carl Wilson, consultant, water quality and treatment, Los Angeles, died Jul. 28, 1958. Prior to entering into private practice, he had for more than 15 years been director of the chemical and biological laboratories of the Los Angeles Dept. of Water & Power. A Life Member of AWWA (joined in 1928), he was active in the California Section, having been the first chairman of its Water Purification Division.

Theodore V. Wood, vice-president and general sales manager, R. D. Wood Co., Philadelphia, died Jul. 2, 1958. He was 55. Born in 1903, he attended Yale University. He entered the employ of R. D. Wood Co. in 1924. He spent several years at the plant and then was transferred to the Philadelphia office in the capacity of sales representative. He came into the Executive Sales Office in 1934, rising to vice-president and general sales manager, a position he held until his death. He had been an AWWA member since 1930.

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Allen, Gerald Stanley, San. Engr., City of Duluth, 411 W. 1st St., Duluth, Minn. (Jr. M. Jul. '58)

Argersinger, Paul Reginald, Pipefitter Foreman, Water Dept., 1040 Manzanita, Pasadena, Calif. (Jul. '58)

Armstrong, Roy N., Warehouse Gen. Foreman, Water & Sewer Dept., 2301 S. Jackson St., Tulsa, Okla. (Jul. '58)

Athersmith, Cyril, Supt., Public Works, McCook, Ill. (Jul. '58)

Badgett, Charles O., Chief Chem. Applications Engr., Industrial Nucleonics Corp., 1205 Chesapeake Ave., Columbus 12, Ohio (Jul. '58)

Barber, Vincent L., Supt. of Water Works, Mechanicville, N.Y. (Jul. '58)

Barton, John V., Water Supt., Water Dept., Box 456, Marlin, Tex. (Jul. '58)

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Brickey, James William, Sales Engr., Layne Northern Co. Inc., 2000 Turner St., Lansing, Mich. (Jul. '58)

Brush, Gorton W., Cons. Engr., 202 Martroy Lane, Wallingford, Pa. (Jul. '58)

Burd, Robert Swanson, Asst. Eng. Specialist, Central Coastal Region, State Water Pollution Control Board, Bank of America Bldg., San Luis Obispo, Calif. (Jr. M. Jul. '58)

Carpenter, William E., Water Production Supervisor, Water Dept., 1040 Manzanita, Pasadena, Calif. (Jul. '58)

Carter, Olen C., San. Engr., Ohio Dept. of Health, 306 Ohio Dept. Bldg., Columbus 15, Ohio (Jul. '58)

Caswell, Keith P., Jr., Civ. Engr. & Land Surveyor, Caswell Eng. Co., 5722 Wayzata Blvd., Minneapolis 27, Minn. (Jul. '58)

Clark, Harry Edward, Mfer.'s Repr., Harry E. Clark & Co., 615 M. & M. Bldg., Houston 2, Tex. (Jul. '58)

Davids, Herbert W.; *see* Suffolk County Dept. of Health

Davis, Herme; *see* Oberlin (Ohio)

Dixon, Ralph E., Mgr., Utilities, 832 Grand Ave., Del Mar, Calif. (Jul. '58)

Douglass, Bernard A., Supt., Water Works Board, Mulga, Ala. (Jul. '58)

Eilers, J. John, City Supt., Montague, Mich. (Jul. '58)

Eliefson, Harold O., Civ. Eng. Assoc., Water Design Div., Dept. of Water & Power, 207 S. Broadway, Los Angeles 12, Calif. (Jul. '58)

Fullis, Earle Warren, Civ. Engr., Eng. Dept., Public Utilities, 19 Queen St., Kingston, Ont. (Jul. '58)

Feuerstein, M. J. Stoel, Director, Cie Interc. ale des Services d'Eau de Zuid-Beveland, Patijnweg 30, Goes, Netherlands (Jul. '58)

Finke, Herbert A., Filter Plant Supt., Munic. Water Works, 6th & Washington Sts., Huntingburg, Ind. (Jul. '58)

Finley, Thomas R., Pres., Finley's Munic. Supply Co. Inc., 1206 W. Pine St., Orlando, Fla. (Jan. '44)

Fisher, Franklin S., Owner, 131 Smoyer Bldg., 422 Cleveland St., Clearwater, Fla. (Jul. '58)

Fritz, John Leland, Water Treatment Operator, Water Dept., Sierra Pacific Power Co., 222 S. Virginia St., Reno, Nev. (Jul. '58)

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Gilberg, Jack Donald, Sales Repr., General Chem. Div., Box 369, Vancouver, Wash. (Jul. '58)

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Great Western Water Service, Warren O. Wagner, Pres., 738 E. Walnut St., Pasadena, Calif. (Corp. M. Jul. '58)

Greaves, Robert W., Mgr., New Jersey Water Service Co., 3 Paterson Ave., Little Falls, N.J. (Jul. '58)

Grusenmeyer, L. Raymond, Supt., Campton Heights Water Service, Box 124, Rohnerville, Calif. (Jul. '58)

Guzman, Ramon M., Special Asst. for San. Eng., Area Public Works Office, Caribbean, US Navy, San Juan, Puerto Rico (Jul. '58)

Hamel, Vernon S., Engr., General Engineering Co., City Bank Bldg., Portage, Wis. (Jul. '58)

Hamilton, William Morgan, Partner, Hamilton-Shultz & Luke, Cons. Engrs., Roebuck Dr., Box 1389, Meridian, Miss. (Jul. '58)

Haviland, Lee F., Supt., Water Works, 2596 N. 400, E. North Ogden, Utah (Jul. '58)

Hemrich, Thomas Louis, Mech. Engr. I, Pumping Station Efficiency, 402 City Hall, Chicago 2, Ill. (Jul. '58)

Hendrix, Thomas K., Sales Engr., Mueller Co., Decatur, Ill. (Jul. '58)

Herchik, Samuel Michael, Water Sales & Field Repr., Water Dept., Cocoa, Fla. (Jul. '58)

Hinton, Howard B., Utilities Supervisor, Escambia Chem. Corp., Box 467, Pensacola, Fla. (Jul. '58)

Hodgins, Burnell L., Civ. Engr., International Water Supply, Ltd., Oakville, Ont. (Jul. '58)

Holcomb, Edward F., Supt., Water Dept., S. Center St., Statesville, N.C. (Jul. '58)

Holloway, Harvey M., Supt., Water Dept., Dothan, Ala. (Jul. '58)

Holmes, H. B., Jr.; *see* Virginia Div. of Water Resources

Jackson, James Allen, San. Engr., State Board of Health, 1330 W. Michigan St., Indianapolis 7, Ind. (Jul. '58)

Jones, E. D., City Mgr., Brownfield, Tex. (Jul. '58)

Kaserman, Harry D., Chief Engr., Water Plant, New Philadelphia, Ohio (Jul. '58)

Kellermann, E. F., Engr., Consumers Water Co., 1826 Ponce de Leon Blvd., Coral Gables, Fla. (Jul. '58)

Kellett, James F., Asst. to the Gen. Sales Mgr., Mueller Co., 512 W. Cerro Gordo, Decatur 70, Ill. (Jul. '58)

Killgore, E. J., Vice-Pres., Edwin Elliot & Co., 560 N. 16th St., Philadelphia 30, Pa. (Jul. '58)

Laird, Edward J., Mech. Engr., Dept. of Water & Sewers, 811 N. Michigan Ave., Chicago, Ill. (Jr. M. Jul. '58)

Langford, Russell H., Chemist, Water Resources Div., US Geological Survey, 510 Rudge-Guenzel Bldg., Lincoln, Neb. (Jul. '58)

Lauman, Richard H., Field Supervisor, Drilling Div., C. W. Lauman & Co., Inc., Bethpage, N.Y. (Jul. '58)

Lemmen, Reese N., Mech. Contracting Estimator, R. L. Spitzley Heating Co., 1200 W. Fort St., Detroit 26, Mich. (Jul. '58)

Long, Bill Conrad, Gen. Mgr. & Plant Supt., El Paso Water Control & Improvement Dist. No. 4, 100 W. Main St., Fabens, Tex. (Jul. '58)

Lootens, Ivan R., Repr., Layne-Northern Co., 2000 Turner St., Lansing 6, Mich. (Jul. '58)

Lottes, Edward J.; *see* Monona Village Water Utility

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(Continued on page 110 P&R)

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- Mechanical Joint Ends

FIG. 551
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- Non-Rising Stem
- Parallel Seats
- Flanged Ends

FIG. 560
- Outside-Screw-and-Yoke
- Rising Stem
- Parallel Seats
- Flanged Ends

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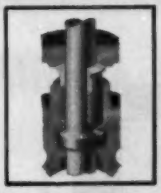

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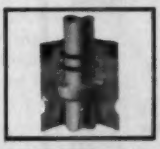

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Lunebach, Robert J., Field Engr., Infilco Inc., 2 W. 46th St., New York 36, N.Y. (Jul. '58)

Lyon, Charles R., Partner, Ruskin Fisher & Assoc., 17962 Aurora Ave., Seattle 33, Wash. (Apr. '56)

Macdonald, Edward George, Sales Engr., Sales Dept., Wallace & Tiernan Ltd., 925 Warden Ave., Toronto 13, Ont. (Jul. '58)

Margolin, Louis, Position Analyst, Dept. of Operating Methods & Safety, Bureau of Water, City Hall, Chicago, Ill. (Jul. '58)

McAllister, Thomas Jay, Salesman, P. B. & S. Chem. Co., 1100 N. Adams, Henderson, Ky. (Jul. '58)

McClure, Henry L., Sr. Water Plant Operator, Elmendorf Air Force Base, Box 758, Star Rte. A, Spenard, Alaska (Jul. '58)

McCollum, Jerald K., Sales Engr., Graver Tank & Mfg. Co., Inc., 5343 McCormick, Box 1764, Houston 1, Tex. (Jul. '58)

McDaniel, Edgar B., Supt., Filtration Plant, 1006 B St., Box 270, St. Albans, W.Va. (Jul. '58)

McLester, Isaac Campbell, Director of Public Works, Water Dept., City Hall, Dyersburg, Tenn. (Jul. '58)

McPherson, Roger Carroll, Chief of Water Pumping Stations, Water Dept., c/o Torresdale F. W. Pumping Station, 8601 State Rd., Philadelphia 36, Pa. (Jul. '58)

Monona Village Water Utility, Edward J. Lottes, Water Supt., 5211 Schluter Rd., Madison 4, Wis. (Munic. Sv. Sub. Jul. '58)

Morgan, Paul E., Assoc. Prof. of Civ. Eng., Iowa State College, 106 Eng. Annex, Ames, Iowa (Jul. '58)

Morris, Willis H., San. Engr., Deputy Chief of Staff Installations, Headquarters Alaskan Air Command, Anchorage, Alaska (Jul. '58)

Mulvihill, Joseph William, Water Meter Repair Foreman, Water Dept., 1040 Manzanita Ave., Pasadena, Calif. (Jul. '58)

Murdoch, John H., III, Public Relations Consultant, State Dept. of Health, 1027 Health & Welfare Bldg., Harrisburg, Pa. (Jul. '58)

Muter, William G., Jr., Engr., Installation Engrs., Goodfellow Air Force Base, 312 Sellers, San Angelo, Tex. (Jul. '58)

Neubauer, George H., Vice-Pres., Ewin Eng. Corp., 504 Dupont Plaza Center, Miami, Fla. (Jul. '58)

Oberlin, City of, Herme Davis, Supt. of Water, City Hall, Oberlin, Ohio (Munic. Sv. Sub. Jul. '58)

Oklahoma Bureau of Water Resources Research, George W. Reid, Director, Univ. of Oklahoma, Norman, Okla. (Corp. M. Jul. '58)

Palmer, Theron L., Supt. & Mgr., Bona Vista Water Improvement Dist., 901 Washington Blvd., Annex 3, Ogden, Utah (Jul. '58)

Pollock, John E., Engr., 249 Franklin St., Tiffin, Ohio (Jul. '58)

Pond, Lloyd B., Director, County Water Dist., Quartz Hill, Calif. (Jul. '58)

Prator, Simpson V., Mgr., Tex-Vit Supply Co., Box 117, Mineral Wells, Tex. (Jul. '58)

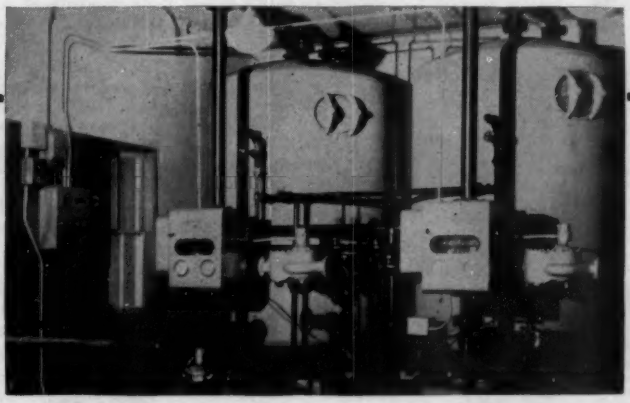
Reed, Ed. L., Cons. Ground Water Hydrologist, Rte. 2, Box 124, Midland, Tex. (Jan. '58)

Reid, George W.; *see* Oklahoma Bureau of Water Resources Research

Rhodes, Ralph L., San. Engr. I, Pennsylvania Dept. of Health, 300 Liberty Ave., Pittsburgh 22, Pa. (Jr. M. Jul. '58)

Richardson, Richard F.; *see* Tarrant Utility Co.

(*Continued on page 112 P&R*)



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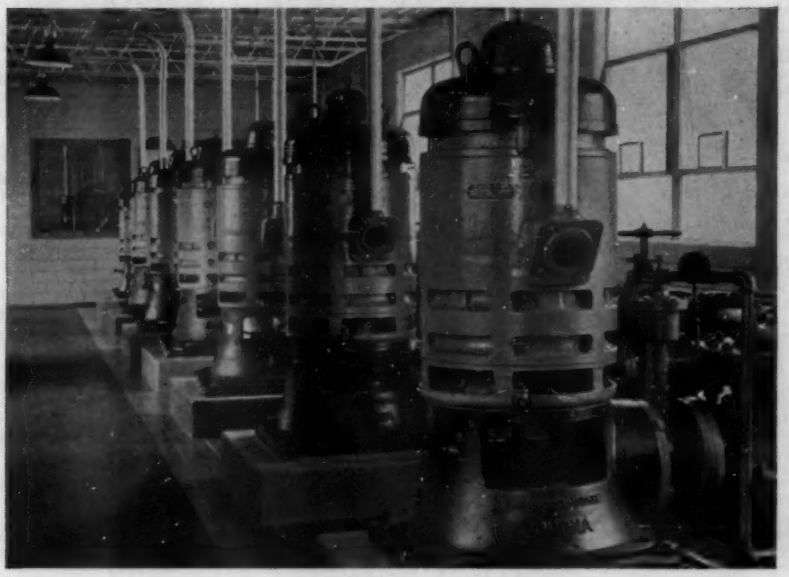

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(Continued from page 110 P&R)

Salinas, Fernando G., Business Mgr., Starr County Water Control and Improvement Dist. No. 2, 505 E. Main St., Rio Grande City, Tex. (Jul. '58)

Schneider, Robert J., Resident Officer in Charge of Constr., Civ. Engr. Corps, US Navy Dist. Public Works Office, US Naval Base, Norfolk 11, Va. (Jr. M. Jul. '58)

Schultz, Herbert C., Gen. Supt., Centriline Corp., 302 W. Oakland Ave., Box 291, Oakland, N.J. (Jul. '58)

Semple, Richard C., Jr., W. Texas Dist. Mgr., Layne Texas Co., 5440 Doniphan Dr., El Paso, Tex. (Jul. '58)

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Smith, W. George, Ontario Sales Mgr., Orenda Industrial Ltd., 17 Haas Rd., Rexdale, Ont. (Jul. '58)

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Tarrant Utility Co., Richard F. Richardson, Mgr., 2215 Jacksboro Hgy., Fort Worth, Tex. (Corp. M. Jul. '58)

Taylor, Jay F., Chief Engr., Multi Metal Wire Cloth Co., Inc., 1350 Garrison Ave., New York 59, N.Y. (Jul. '58)

Terrell, Howard, Branch Plant Mgr., Brooks Products of Texas, Inc., 4817 Holmes Rd., Houston, Tex. (Jul. '58)

Thoreson, Robert F., City Engr. & Director of Public Works, 8650 California Ave., South Gate, Calif. (Jul. '58)

Tremblay, Norman Robert, Jr. Engr., Southern California Water Co., 11911 S. Vermont Ave., Los Angeles 44, Calif. (Jul. '58)

Trenda, George, Water Chem. Engr., South Dist. Filtration Plant, 3300 E. Cheltenham Pl., Chicago, Ill. (Jul. '58)

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Waananen, Arvi O., Hydraulic Engr., US Geological Survey, Dept. of the Interior, 2224 General Services Bldg., Washington 25, D.C. (Jul. '58)

Wachs, Arthur J., Field Engr., Pitometer Assocs., 50 Church St., New York, N.Y. (Jul. '58)

Wagner, Francis S., Field Mgr., San Dieguito Irrigation Dist., 669 —2nd St., Encinitas, Calif. (Jul. '58)

Wagner, Warren O.: *see* Great Western Water Service

Walker, Albert A., Constr. Engr., Water Dept., 2863 Municipal St., Dallas, Tex. (Jul. '58)

Webber, E. Douglas, Partner, Walker & Webber, Cons. Civ. Engrs., 1894 W. Broadway, Vancouver 9, B.C. (Jul. '58)

Weisberg, Eugene, Asst. Research Professor, Environmental Sanitation, Graduate School of Public Health, Univ. of Pittsburgh, Pittsburgh, Pa. (Oct. '58)

Whitaker, Mark B., Gen. Mgr., Utilities Board, 626 Gay St., S.W., Knoxville 1, Tenn. (Jul. '58)

Williams, Perce Wilfred, Staff Mgr., Canadian Johns Manville Co., Ltd., 568 Lakeshore Rd., Port Credit, Ont. (Jul. '58)

Wood, Edna D., Director, Microbiology Service Labs., 5420 Calhoun, Houston 21, Tex. (Jul. '58)

Wood, Franklin Glen, Water Supt., 103 W. Davis, Mesquite, Tex. (Jul. '58)

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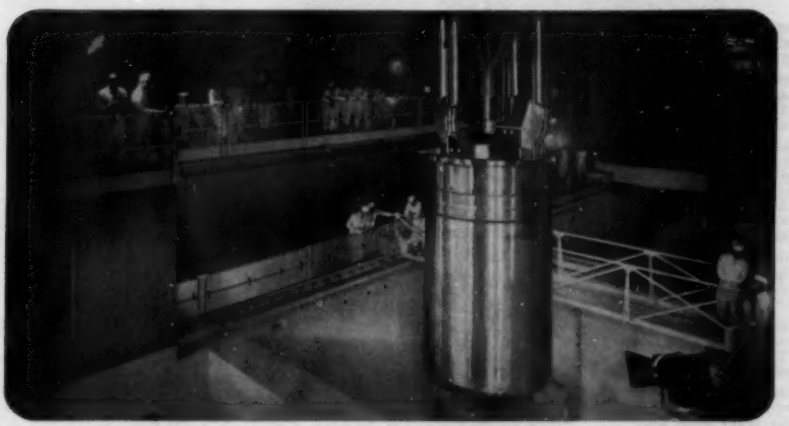

The water which shields and surrounds this nuclear core is deionized by AMBERLITE Monobed ion exchange resin units.

At the SHIPPINGPORT ATOMIC POWER STATION—where water conditioning must be efficient . . . dependable . . . fool-proof—AMBERLITE Ion Exchange Resins are used.

In this plant, built jointly by the Duquesne Light Company and the United States Atomic Energy Commission, water, specially conditioned, is the medium through which atomic energy ultimately becomes electrical energy.

After preliminary treatment of the water, calcium and magnesium ions are removed by two softening tanks containing AMBERLITE IR-120 cation exchange resin. The water then goes to a mixed bed deionization unit of AMBERLITE Monobed resin (a mixture of AMBERLITE IR-120 and IRA-400) which removes both anions and cations. The water is now ion-free. Possible pick-up of metallic ions and their build-up is controlled by passing part of the water used in the plant's primary loop through a separate mixed bed ion exchange unit containing AMBERLITE XE-154 (a specially prepared mixture of AMBERLITE IR-120 in the lithium form and AMBERLITE IRA-400 in the hydroxyl form) which raises the pH well above neutrality as a safeguard against corrosion.

Whatever your water conditioning problem, your engineering company specializing in water conditioning is qualified by experience to recommend how AMBERLITE resins can best serve your special needs. For detailed information about AMBERLITE resins, write for our booklet *"If You Use Water"*.

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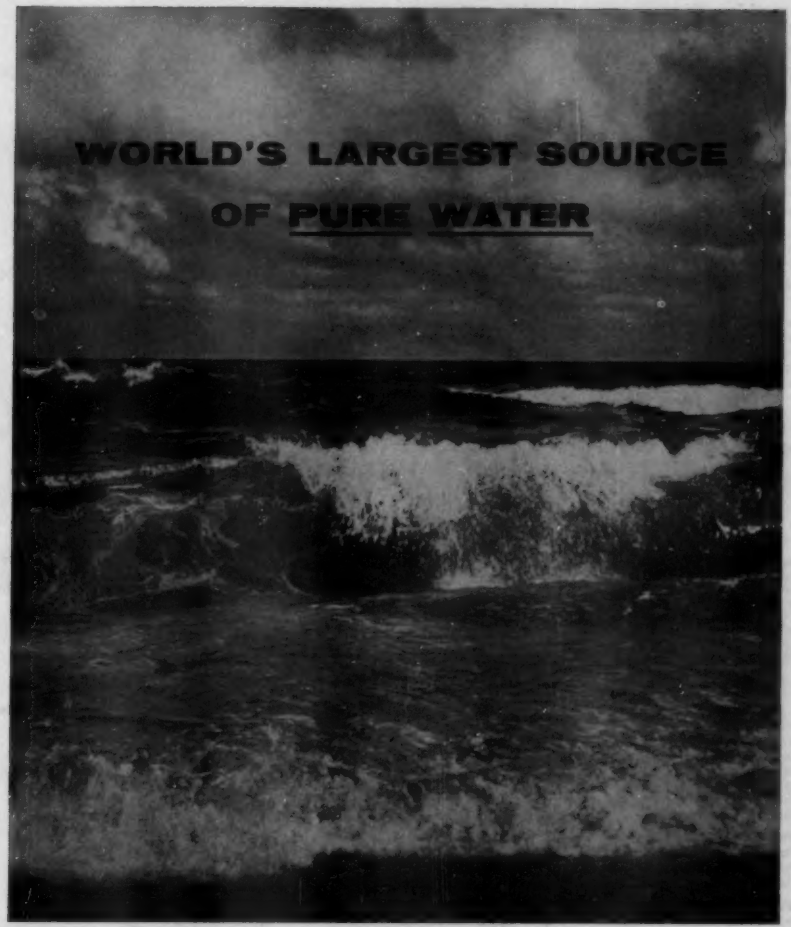

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Golden-Anderson Valve Specialty Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes:
Builders-Providence, Inc. (Div., B-I-F Industries, Inc.)
Burgess-Manning Co., Penn Instruments Div.
Simplex Valve & Meter Co.

Waterproofing:
Inertol Co., Inc.
Koppers Co., Inc.
Plastics & Coal Chemicals Div.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
LaMotte Chem. Products Co.
W. A. Taylor & Co.
Wallace & Tiernan Inc.

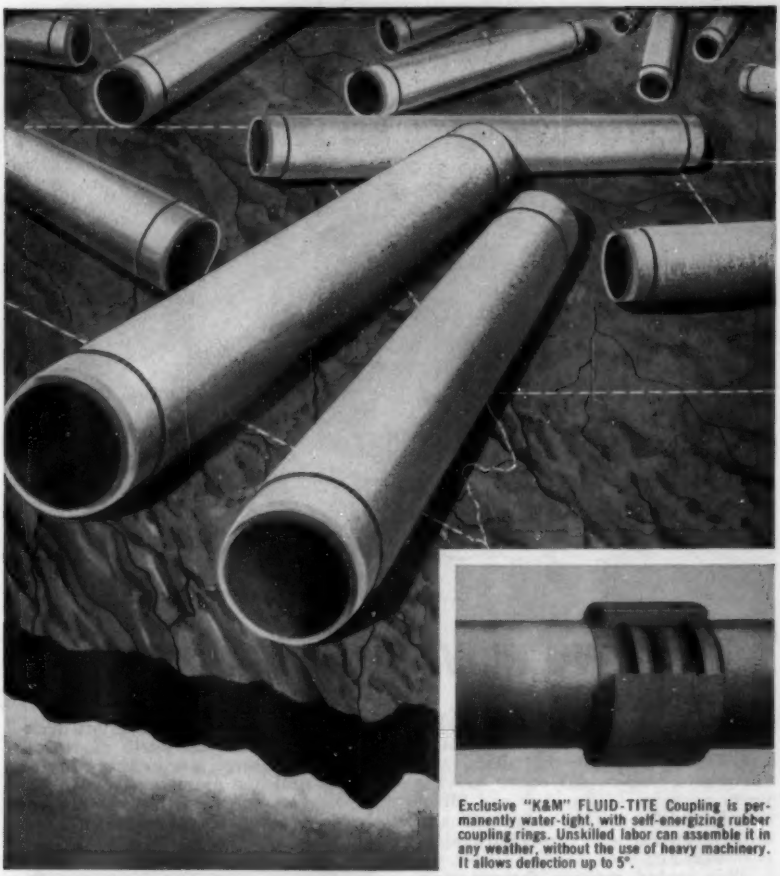
Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite: see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1957 AWWA Directory.



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From Los Angeles, Cal. to Bar Harbor, Me.

Modern communities all over the country are joining the trend to the modern pipe—"K&M" Asbestos-Cement Pressure Pipe with FLUID-TITE Coupling

- Permanent, water-tight connections
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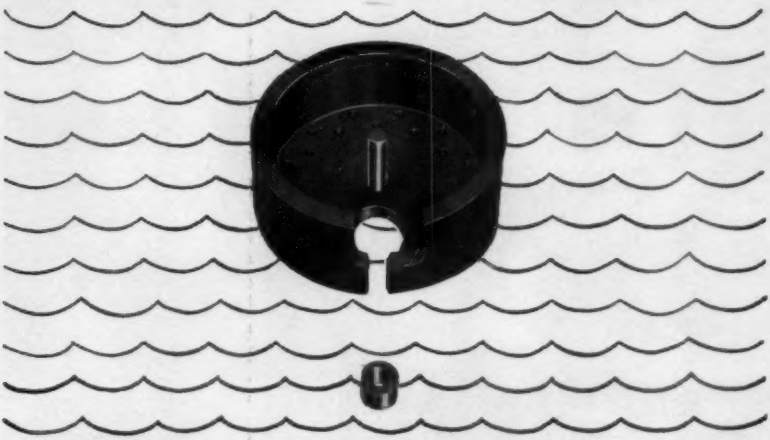
ROCKWELL SEALED REGISTER WATER METERS

Less to wear—Less to repair!



only two moving parts in water

The Rockwell Sealed Register Meter has only two moving parts in the flowing stream—the piston and the piston roller. All other moving parts operate—clean, dry and lubricated for life—within a hermetically sealed register casing protected against corrosion and erosion.

This sealed register forever ends condensation troubles. There can be no fogging or clouding to obscure readings. A powerful magnetic drive eliminates the need for a stuffing box, an exposed intermediate gear train and driving dog.

Simple isn't it? . . . and more accurate, too, for fewer parts mean less friction and wear, a smoother running meter and one more sensitive to low flows. Get full facts now—write for bulletin to Rockwell Manufacturing Company, Pittsburgh 8, Pa.

SEALED REGISTER WATER METER
another fine product by
ROCKWELL

Top View

Side View

End View

The solution to this problem is always the same... but

Water Treatment Problems are different

No two water treatment problems are exactly alike. The right solution to each can only be arrived at after a careful study of local conditions. Variables such as raw water consumption, rate of flow and results required automatically rule out the cure-all approach. The installation shown below is a good example of how equipment should be selected to suit the job ...and not vice versa.

Duncan, Oklahoma

third Clariflocculator added on repeat order

Shown in the foreground above is a new 85′ diam. x 10′ swd Dorrco Clariflocculator with a capacity of 4 MGD, recently installed at the Duncan, Oklahoma, Water Treatment Plant. Added to two previously installed 60′ diam. units, each rated at 2 MGD, it doubles the treatment capacity of this modern plant. Repeat orders like this are the best evidence of the efficiency of Dorr-Oliver equipment. For more information, write to Dorr-Oliver Incorporated, Stamford, Connecticut.

Consulting Engineers: Hudgins-Thompson-Ball & Associates, Oklahoma City, Okla.
Contractor: Acme Construction Company, Oklahoma City, Okla.

Every day over 8½ billion gallons of water are treated by Dorr-Oliver equipment

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Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
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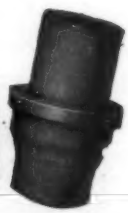
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